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MORE INTERESTING AND PRACTICAL MECHANICS FOR THE HIGH SCHOOL.*

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The man who, in these days, is to take his proper place in the community in which he lives, who is to be a producer and giver as well as consumer and receiver, must be familiar with the larger principles of mechanics. The number of mechanical appliances in common daily use is multiplying with almost incredible rapidity; automatic machinery with its resulting rapidity and cheapness of output is everywhere replacing hand labor in manufacturing establishments; facilities for transportation and communication are being developed in even the smallest villages; new bridges, subways, public buildings, etc., etc., are everywhere in process of design or construction. Our business and professional men, our public officials, in fact our men of affairs of whatever kind are constantly placed in situations which demand from them *industrial* and *mechanical intelligence.*

We rely upon our public schools for the education of the great body of our people. Hence it immediately becomes a pertinent question: "What are our public schools and particularly our High Schools doing to develop industrial and mechanical intelligence?"

Now I do not wish to be understood as suggesting that our High Schools should provide instruction in the particular activities in which its graduates are likely to engage. Such instruction *might* produce a few skilled artisans; it would hardly develop broad intelligence. I am not suggesting trade courses

*Abstract of paper read before the New York State Science Teachers' Association in New York City, Dec. 26, 1906.

or even technical instruction. But I do feel that our High School courses—and since that is the subject with which we are immediately concerned—that our high school course in Physics in particular, should be suited to the needs of the pupils; that it should connect *immediately* and *in no uncertain half-defined way,* with life problems; that it should furnish a broad and really intelligent grasp of such fundamental practical ideas as the principles governing the distribution of forces in structures, the transmission, transformation, and utilization of energy together with the conditions which control the losses during such processes; and above all, that it should provide such opportunities for experimenting with *real* problems in an *actual* way as shall develop the point of view and *resourcefulness* necessary to meet successfully the rapidly changing conditions characteristic of the age. The days of apprenticeship are past, for the system is too slow for modern progress. Before the period of the apprenticehip is completed, the methods learned are out of date. The need is, nowadays, for quick, resourceful, broadly trained minds which are capable of rapid development along several lines.

Physics is admirably adapted by the nature of its subject matter to be one of the most effective agents in providing the type of training just suggested. It may be used for the purpose without sacrificing in any way the cultivation of judgment, of regard for truth, of precision, and of those other intellectual and moral qualities for which the physics teacher strives and in the capacity for which he believes his subject to be rich almost beyond comparison. And yet we must admit that physics teaching as now generally conducted in our High Schools, is not contributing greatly to this end. Several reasons in my judgment may be advanced for this failure, foremost among which should be mentioned the neglect on the part of so many teachers of physics to provide proper instruction in mechanics.

During the past five years, several hundred Physics laboratory notebooks submitted to the College Entrance Examinations Board from all sections of the country have passed through my hands. These books are always better evidence of the teacher's conception of his Physics laboratory work, of the ideals he has created and of the spirit he has succeeded in arousing than they are of the mental equipment of the pupils The most striking general conclusion which they seem to point

is what may be termed the too general indifference of Physics teachers toward the subject of mechanics.

Under the very broad provisions of the Examinations Board regarding the distribution of the laboratory exercises among the subdivisions of Physics, mechanics is frequently minimized to provide more time for light or sound. Not infrequently the entire laboratory work in this subject is represented by three or four exercises in measurements—such as the distance between two fixed points, the dimensions of a block, or the diameter of a cylinder or sphere—six or seven exercises in determining specific gravity, an illustration of the parallelogram of forces, and Boyle's Law. There is nowhere any evidence of an attempt to show the application of the two last mentioned.

Those books which indicate greater time spent on Mechanics represent an attempt to cover a *larger proportion of the work now laid down* in one of the several lists of laboratory exercises regarded as suitable for secondary schools, rather than any serious attempt on the part of the teacher to so modify the character of the teaching as to make this subject really useful either for information or for training. In none of them is there evidence of an endeavor to keep pace with the changes in the interests of pupils, to recognize the different surroundings which now control their lives, or to provide for the practical problems which they are preparing to meet. The average index of exercises in mechanics differs in no essential respect from the original list which appeared in that now ancient classic—"The Report of the Committee of Ten."

Again the emphasis placed upon the several subdivisions of mechanics is not properly distributed. The time available for Physics in the High School is necessarily short, and in teaching mechanics, therefore, the great principles which are far reaching in their applications, should be emphasized and the relatively unimportant portions passed over lightly. Under such circumstances, what could be more absurd than a selection of laboratory exercises which, out of a total of 29 possible exercises in Mechanics, gives 8 or nearly 30 per cent of them to specific gravity, 4 or over 14 per cent to special levers, 6 or nearly 21 per cent to the technical subject of the properties of materials; as against 7 per cent to forces other than parallel, and none whatever to the laws of rotating bodies, or to the great principle of energy transfer, work, efficiency, and the conservation of energy?

Then, also, too much time is spent in the representation of mechanics, dawdling over trivial and obvious facts. We should credit our pupils with a reasonable amount of common sense and an ability to "rise to the occasion" if required. Propositions which, when fairly presented, are grasped at once in all essential details, do not require demonstration. For example, what pupil needs actual experimental proof that the upward reaction at the fulcrum of a lever is equal to the sum of all forces downward? Or to carry through separate exercises on the effect of the weight of a lever, or on each case of the artificial classification into levers of the first, second, or third class? To be sure these things *may be* so fogged in a haze of directions that both pupil and teacher are worried. But the difficulty here arises not from the fact that the *mechanics is too hard* but because attention is focused upon carrying out a set, rigid procedure without slip or omission. All *actual* levers have weight; *all* obey the common law of moments. Teach the pupil what is meant by moment of force and by moment arm; show him how to pick out the moment arm with respect to a given axis; put the whole case fairly before him and let him use some initiative. In nearly every instance he will readily find his own way, and will see for himself that the weights of the parts of structures always come in as additional forces with moments which must not be omitted, and that certain general conditions must always be met in any arrangement of forces.

The method here suggested of *taking problems in the large* and allowing for special conditions as they arise without separate demonstration is of the utmost importance to the teaching of mechanics. In the first place it concentrates attention on main principles and crowds special details into the background where they properly belong. It cultivates resourcefulness. And finally it saves time so that exercises of real practical value may be introduced, which shall arouse the pupil's interest and directly connect his study of mechanics with the problems and appliances of his daily life.

Finally, and perhaps I ought to say, *chiefly*, Mechanics teaching is not now accomplishing its legitimate share in the training of High School pupils because we teachers fail so frequently to intimately connect the class-room and laboratory work with the daily experiences and interests of the pupils. All young people are interested in explanations of large enterprises; in things that

"*go*" and things that "do." But our laboratory apparatus illustrates academic conditions and fails to suggest the possibility of practical applications. Our pupils therefore soon fall into the habit of regarding their mechanics much as they do certain other subjects in the school curriculum, as a thing to be endured rather than enjoyed, to be passed with credit if possible, but under no circumstances as anything which exists other than in the abstract to be always shut in by the class-room or laboratory door.

Now what should be done to put the mechanics teaching "in phase" with the conditions of the day so that it may become as it properly should, a valuable agent in High School education? I am hoping much from the so-called "New Movement among Physics Teachers." It is a question, too, which in my opinion this organization might well take up. But whatever the source of the movement, two things must be accomplished: many teachers must be roused to a better conception of the aims and possibilities of mechanics teaching; and sweeping changes must be effected in subject matter and in the manner of presentation. Toward this movement I wish to offer the following suggestions:

1. That all formal exercises in measurements of lengths, diameters, etc., should be omitted, and such measurements taken only as required for the purposes of some actual experiment. Only when done in this way as a means to a clearly defined end do they possess value or interest.

2. That the laboratory exercises in specific gravity determinations and allied ideas be not more than two in number. These should establish the principle of the buoyant force of liquids and fix the idea of the term specific gravity. Any loss which seems to be incurred through this reduction in the number of such exercises will be more than repaid by the exercises which replace them.

3. That time be economized through a better grouping of the facts of mechanics. For example, all the somewhat scattered idea of statics may be grouped around the central idea that the forces acting must *produce no change* in the existing condition of motion of the body acted upon. It follows therefore that the forces in any given direction must always be balanced by equal forces in the opposite direction; and that any tendency which the forces may have to produce rotation in one direction must be counteracted by an equal moment in the opposite direc-

tion. In other words we have the general conditions for equilibrium in a plane that the sum of the X forces, the sum of the Y forces, and the sum of the moments must each be zero. This is a central idea that sooner or later in his study every pupil should obtain. The parallelogram law, parallel forces, and non-concurrent forces may then all be reviewed as special arrngements of forces, coming under these general conditions.

Again the idea that action and reaction are always equal and opposite is a convenient starting point for teaching not only statics but also dynamics where *inertia reactions* must be considered.

4. That instruction be given in the dynamics of rotating bodies. This is too important and too general an idea to be omitted as is now generally done. The laws of rotational acceleration, and of the relations of moment of force, rotational inertia and angular acceleration should be taught at least in their general aspects, as well as the corresponding cases of motion of translation. Such topics as the stored energy of the rotating parts of a machine, energy relations in starting and stopping machinery, etc., should also be discussed.

5. That the general laws of statics discussed in the class-room and lecture periods, should be applied in the laboratory through a study of models of structures which reproduce as nearly as possible the conditions of actual practics. These models may be readily constructed at small cost and should always be large enough to suggest possibilities of actual use as then only will they command respect and arouse interest. As suitable subjects for models may be suggested various forms of trusses, derricks, cranes, arches, etc. And here it should be said that it is not necessary and indeed not often desirable that there be duplicates enough for all members of a section to be doing the same thing at the same time, or that any pupil should work experimentally with all models. The ideas are sufficiently similar so that no confusion need arise, and much value may be obtained through discussions before the class of the results obtained by different observers. Again it is not necessary that a student made a complete study of a given model. The need in secondary instruction is not for precise knowledge of theory, but rather of *the thing itself;* what it means, what it does, what are its effects and applications. Hence a number of studies may be made of each model, each one designed to find out one definite

point. In this way the work may be made as easy or as difficult as desired, and may be made to fit in with any schedule of laboratory time.

6. That each student be provided opportunity to study the transmission and utilization of energy, to trace and measure the loss in all these processes and to study ways of reducing such losses. The facilities for this study will depend greatly upon the equipment and power supply of the school. In any case, it is not difficult to provide various small gear, belt, and sprocket machines which may be operated by means of cords passing around drums attached to the shafts and supporting scale pans. The sprocket wheels of an old bicycle which may be obtained at small cost from any junk shop provides apparatus for several excellent exercises. These small machines should always be made up from commercial parts and should not be fitted too freely with special ball-bearing or friction reducing devices. They should be large enough for some actual service. Let the pupil deal with the conditions which obtain in practice. The one experiment of this sort most often used, that of the efficiency test of a system of pulleys, done as it usually is with an eight-ounce balance and special cone-bearing pulleys giving an efficiency that is absurdly high seems to me in these days to be almost if not quite worse than nothing. If the experiment is done let it be with a half-inch rope, a heavy weight and the pulley sheaves of common use.

Where the equipment of the school will permit, this line of study may be extended to a study of speeds and friction of shafting, the general details of the school power plant, efficiency tests of electric and water motors, etc. The teacher should not feel, however, that this larger equipment is absolutely essential to good instruction in the sort of mechanics here suggested. Excellent results may be obtained with the small devices mentioned above which are surely available for every laboratory.

(NOTE: In conclusion, to illustrate the type of instruction suggested as needed, the speaker exhibited lantern slides showing models of a simple truss, roof truss, crane, and arch now in use at Pratt Institute, also of a screw jack arranged for an efficiency test, and of an apparatus for studying rotary motion, and the kinetic energy of a rotating body. These models and suggestions for accompanying laboratory exercises will be shown in later numbers of SCHOOL SCIENCE AND MATHEMATICS.)

CURRENT TENDENCIES IN SECONDARY MATHEMATICS IN ITALY.*

By J. W. A. Young.

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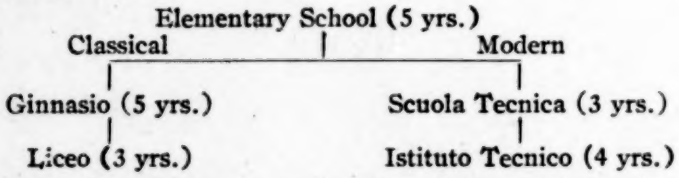
In the world wide forward movement in the teaching of mathematics, in the midst of which we stand, each nation must deal with this teaching according to local conditions, yet many of its problems are common to all nations, and each finds encouragement and moral support in the progress made beyond its borders. Consequently it is not strange that I can begin this brief report which I bring you from Italy today with the statement that our own American movement is not unfelt there, but is cited at the beginning of the directions to the Royal Commission, of which I shall speak later.

The following table indicates the names and sequence of the Italian schools:



I discuss the program in mathematics of the classical schools only, in which somewhat less mathematics is taught than in the others.

The subjects taught and their distribution are indicated below:

Ginnasio						Liceo			
Class	I	II	III	IV	V	I	II	III	Total
Age	12	13	14	15	16	17	18	19	
1900									
Hours per week	2	2	2	2	2	4	3	2	19
	Arithmetic.			Theo. Arith. (lit.) Plane Geometry		Algebra Pl. & Solid Geom.		Pl. Trig.	
1904									
Hours per week	"					4	4	3	21
						Algebra Pl. & S.G. Sol. G. Pl. & Sph. Trigonometry			

Chief changes:

*Address before the Mathematics Section C. A. S. & M. Teachers, Nov. 30, 1906.

1. The time allotted to mathematics is increased. (The additional time is given to algebra and trigonometry.)

2. The time for "fusion" of plane and solid geometry is reduced from two years to one.

(The interweaving of plane and solid geometry has been urged by the Italians for some little time and in the curriculum of 1900, at the instance of the society of teachers, *Mathesis,* opportunity was given to do so during two years.)*

3. In the curriculum of 1900, the geometric treatment of measures is assigned to the second year of the *Liceo* and it is forbidden to make applications of arithmetic or algebra to geometry earlier. In the new curriculum the treatment of measures is moved back to first year of the *Liceo* and the prohibition no longer appears.

4. The new program gives much fuller pedagogic instructions than the old, including the direction that the exercises should be so selected as to show the utility of mathematics in the common affairs of life and in the study of the phenomena of nature. No graphs are included.

This brief sketch may serve to give some idea of the condition of affairs found by the Royal Commission recently appointed to study the whole subject of reform in secondary schools. On March 27, 1906, this Commission made public the first results of its work in the form of a long list of questions covering the entire field and addressed to all interested. Many of the questions relative to mathematics are of a decidedly "leading" character and no better account of the trend of thought concerning the teaching of mathematics in Italy can be given than to reproduce these questions (in condensed form) herewith:

1. In arithmetic, should not less stress be laid on enunciation of rules and definitions and abstract descriptions of processes?

2. What place should be given to theoretic arithmetic? In so far as it consists of demonstration of processes of arithmetic, should it not be treated as an application of algebra?

3. Would it not be better if geometry were taught by the same instructor throughout the secondary school, instead of one in the *ginnasio* and another in the *liceo?*

*For specimens of "fused" treatment see: Paolis, Elementi di Geometria, Turin, 1884. Lazzeri e Bassani, Elementi di Geometria, Livorno 1898. Veronese, Elementi di Geometria, 2nd ed., Padua, 1900. Méray, Nouveaux Éléments de Géométrie, 2nd ed., Dijon, 1903.

4. In teaching geometry, would it not be desirable to lay more stress on graphic exercises, both in solution of problems and in verification of propositions demonstrated?

5. Would it not be well to omit proof of propositions already intuitively evident to pupils?

6. What has been the effect on mathematics of the freedom of election between Greek and mathematics in the last two years of the *liceo?*

7. In algebra, would it not be better, instead of beginning with generalities concerning negative numbers, followed by operations on polynomials, powers, radicals, etc., to proceed at once to solution of equations, developing the theory as required by them?

8. What is your opinion of the so-called "fusion" of plane and solid geometry?

9. What place should be given to trigonometry? Is it desirable that the little which is given should be distributed, as now, over three years?

10. Should proportion be treated according to the 5th Book of Euclid? How should the concept of irrational number be introduced?

11. Does it not seem well to you that place should be made in secondary instruction for the fundamental notions of graphic representation of functions and the concept of first and second derivatives?

12. What weight do you give to the wide-spread opinion that only pupils with special aptitude can profitably study mathematics in the secondary school? In how far is this opinion due to defects in the instruction?

13. What means are best to create and augment interest in mathematics? Would it not be efficacious, to teach from the very beginning, the various parts of the subject in close relations with their applications, putting the purpose they serve into the foreground?

14. To what extent are notes on the history of mathematics useful, either in exciting the interest of pupils or contributing to their culture?

15. Should written examinations in mathematics be restored in all classes?

16. What ones of the texts in current use do you regard as didactically the best?

What the character of the replies will be and what their effect on instruction will be, remains to be seen, but that the Commission itself has its face turned in the direction of less prominence for the abstract, more use of the concrete, introduction of graphic methods, and emphasis upon applications, is sufficiently evident.

NOTE ON THE GRIDIRON PENDULUM.

By C. F. Adams,

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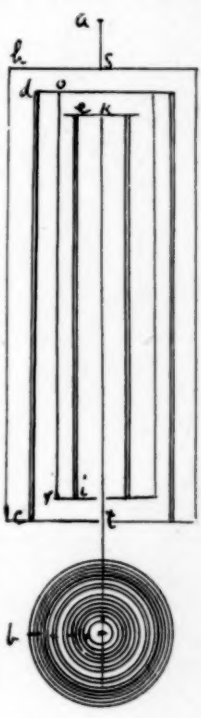
The gridiron pendulum is practically out of date; but for many years it has been a favorite illustration in text books of difference in expansion of different metals. Did it ever occur to many of us that the nine rod pendulum of brass and iron is impracticable, if not impossible? A simple calculation will make this clear. Let L=length of the pendulum from *a* to *b*, point of suspension to center of oscillation.



L=$as+hc+tb$, all iron. Let l=length of brass.

The extra length of iron in the pendulum= l also.

If we take the coefficients of iron and brass as 12 and 18 (millionths) we have the equation $12(L+l)=18l$, the expansion of the iron and brass being equal.

$$l=2L$$

This means that the two brass rods on either side must equal in length twice the length of the pendulum, which is of course impossible. If, however, we use 11 and 19 as representing the coefficients of expansion, which is perhaps more nearly the truth.

$$l=1.4L.$$

The construction of a genuine gridiron pendulum on this supposition is virtually impractical. I wonder how many genuine gridiron pendulums the reader has ever seen!

HIGH EXPLOSIVES.*

By Augustus Klock,

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The chemistry of explosives involves some of the most important laws and principles of chemistry. We deal, for the most part, with substances that are endothermous with respect to the products of their decomposition, these products being, in the most effective explosives, gases that are invisible.

"An explosion takes place when by some mechanical or chemical agency a body is suddenly converted into the gaseous state; the quantity of heat, the quantity of gases developed and the time within which this takes place, determines the force of the explosion. An explosive is, therefore, a body that possesses the property of liberating suddenly large quantities of gas and heat and by their action is capable of performing work."

Explosives are divided into two groups.

I. Low explosives; directly exploding materials such as gunpowder.

II. High explosives; indirectly exploding substances such as guncotton, the highest effect of which is produced by the use of an intermediate body called a detonator.

The pressure of a given quantity of gas is according to Gay Lussac's Law proportional to its absolute temperature. The greater, therefore, the amount of heat that is generated in a certain quantity of gas, the higher will the pressure of the gas become. The heat produced during the explosion can, consequently, be taken as a measure of the theoretical strength of an explosive. The duration of explosion becomes a most important factor in this last consideration, because the shorter the time in which the explosion takes place (in other words, the shorter the time which the body takes to turn completely into gas), the more heat remains to augment the pressure of the gas.

The speed of explosion for different explosives runs about as follows:

A kilogram cube of gunpowder, 1-100 second
A kilogram cube of dynamite, 1-50000 second
A kilogram cube of guncotton, 1-50000 second.

*This article is based on material gathered by the writer while in the employ of a large powder manufactory and was read in a modified form at a recent meeting of the New England Association of Chemistry Teachers. Mr. Klock is now secretary of this Association. —Editor.

When it is remembered that in the above 1-50000 of a second, a high explosive like nitroglycerin (the essential constituent of dynamite) forms a volume of gas that at the very high temperature of the explosion tends to occupy a volume nearly 20,000 times the original volume, one can more easily understand the tremendous effect produced by such an explosive.

GUNPOWDER OR BLACK POWDER.

Gunpowder is supposed to have been invented by the Chinese; but Guttman, one of the best authorities on its history, concludes it is rather certain that the Chinese did not invent it. It undoubtedly had its origin in Greek fire which was used in the Orient as early as the year 711 A. D. This Greek fire had practically the same composition as gunpowder. The following percentages of the constituents in each will indicate the similarity.

According to Marcus Graecus,

	Greek Fire.	Modern Gunpowder.
Sulphur,	11	10
Carbon,	22	16
Saltpeter,	67	74

The method of manufacture of black powder, its properties and forms, are so familiar to every chemistry teacher that they are omitted here. It is well, however, to review the fact that the reaction for explosion of confined gunpowder is very different from that of gunpowder exploded in the open. The reaction for the unconfined explosion is represented by: $2KNO_3+3C+S=3CO_2+N_2+K_2S$. While the reaction of the explosion confined as in a gun barrel is represented by: $16KNO_3+21C+5S=5K_2CO_3+13CO_2+K_2CO_4+3CO+2K_2S_2+8N_2$. These equations express the quantitative relation between the powder constituents and the products of explosion.

GUNCOTTON.

Guncotton is a typical high explosive. "The manufacture of guncotton and of nearly all nitro-compounds consists essentially in immersing a prime material (cotton, glycerin and similar materials) in a mixture of nitric and sulphuric acids and allowing the nitric acid to act upon it for a more or less prolonged time. The explosive body thus formed is then separated from the spent acid and washed very thoroughly."

The equation for the reaction of formation of guncotton is: $C_{12}H_{20}O_{10}+6HNO_3 = C_{12}H_{14}O_4(O.NO_2)_6+6H_2O$.

From this we see that six atoms of hydrogen have been replaced by six nitro-groups (NO_2), six molecules of water being formed at the same time.

In order to prepare a nitro-compound it would seem from the above reaction that nitric acid only was necessary for the nitration. It will be seen, however, that water is formed at the same time and this would constantly dilute the concentrated nitric acid necessary to the reaction. Sulphuric acid is, therefore, added in considerable quantity, the purpose of which is solely to take up the water formed by the reaction and thus maintain the high concentration of the nitric acid. Guncotton was invented by Schönbein in 1846. He used a mixed acid consisting of 75 per cent concentrated sulphuric acid and 25 per cent concentrated nitric acid, the specific gravities of which were 1.84 and 1.45 respectively, practically the same as that of the concentrated acids of our laboratories. This mixed acid is a drastic liquid, difficult to handle, giving off troublesome fumes.

The cotton used for making guncotton is from three sources:

I. Cotton from the pod.

II. The so-called "shoddy" cotton.

III. The "cop-waste" from cotton spinning or the clippings from knitting mills.

The last source is the most important. This, being at first covered with grease, is given a thorough boiling in caustic soda (9 hours). The alkali is then drawn off and the cotton is boiled in water (8 hours). It is then washed in a centrifugal machine, thus removing most of the water; finally it is placed on a wire netting and dried until it contains less than one half of one per cent of moisture. Usually, before the final drying, the cotton is run through a picking machine that straightens out the tangled mass of cotton and opens up the knots and rolls. After the picking the cotton is of fine loose quality. The cotton is now nitrated either in dipping pots or centrifugals. A centrifugal for this purpose has a perforated wrought iron basket, about three feet in diameter, that revolves within a cast iron case; a discharge pipe operated by an exhauster carries away the fumes formed in the process. The mixed acid is poured into the centrifugal until it is nearly full. Then the cotton (about 20 lbs.) is put in

through a hole in the top of the case. The nitration then proceeds and is finished in about thirty minutes.

The spent acid is now drawn off, the cover closed, and the centrifugal is set revolving rapidly to wring out most of the remaining acid.

The guncotton, as wrung out by the centrifugal, is now removed from the centrifugal machine with iron forks, generally scissors-shaped, and placed in a washing machine called a beater. This has paddle wheels to stir the cotton as a steady stream of water flows through the machine. This treatment is continued until the cotton will not redden litmus paper.

The guncotton still, however, contains acid, especially within its tubular fibres that have maintained the structure of the cotton. To eliminate this acid, it is boiled in a two per cent sodium carbonate solution for eight hours. In the early days of guncotton it was assumed that guncotton is entirely free from acid at this stage; but as a matter of fact it is not, and many serious explosions, due to decomposition brought on by the presence of acid, taught the early experimenters that further treatment is necessary. Nowadays, therefore, the guncotton, after its boiling in sodium carbonate, is put into a pulping machine, or "rag engine," which tears the threads into fine bits. Next it is thoroughly washed in a poacher and often is afterwards treated with limewater, precipitated calcium carbonate, and sodium hydroxide, all in small quantities. For military purposes this guncotton is now pressed into cakes by molding machines under tremendous hydraulic pressure. The guncotton as kept and stored contains at least 20 per cent of moisture, for in this condition it will explode (when detonated) with the same violence as when dry, and it is then safe from fire and safe to transport.

Properties of guncotton:—Insoluble in water, alcohol or ether; soluble in acetone or benzol; resembles ordinary cotton but is harsher to the feel; not readily exploded by shocks but violently so when detonated. Its price is about one dollar per pound.

The formula for cellulose has long been doubtful. The first supposed formula, was $C_6H_{10}O_5$; this when fully nitrated would give tri-nitro-cellulose and the next lower di-nitro-cellulose. Eder found, however, several nitro-compounds in which the percentage of nitrogen was between that of tri-nitro-cellulose and di-nitro-cellulose. He therefore, doubled the formula for cellulose to $C_{12}H_{20}O_{10}$, and while some experimenters have suggested

still higher values, this formula seems most generally accepted. Eder produced five different kinds of nitro-cellulose as follows:

		Per cent.		
$C_{12}H_{14}O_4(O.NO_2)_6$	Hexa-nitro-cellulose,	14.14	N,	Guncotton
$C_{12}H_{15}O_5(O.NO_2)_5$	Penta-nitro-cellulose,	12.75	N,	Collodion Cotton
$C_{12}H_{16}O_6(O.NO_2)_4$	Tetra-nitro-cellulose,	11.11	N,	Collodion Cotton
$C_{12}H_{17}O_7(O.NO_2)_3$	Tri-nitro-cellulose,	9.15	N,	Collodion Cotton
$C_{12}H_{18}O_8(O.NO_2)_2$	Di-nitro-cellulose	6.76	N,	Collodion Cotton

The guncotton of which we have been speaking is hexa-nitro-cellulose. All the others are forms of collodion cotton, which differs from true guncotton in being soluble in mixture of ether and alcohol. Collodion cotton is called pyroxylin, and is made from cotton, nitrating with a mixed acid of proportions quite different from that used in making guncotton. The proportions are 50 per cent concentrated sulphuric acid and 50 per cent concentrated nitric acid; and the nitration is carried on for a longer time. Collodion cotton is used for making collodion, celluloid and smokeless powders.

SMOKELESS POWDERS.

These were invented in 1886. They are usually forms of nitro-cellulose (collodion cotton) treated in some way to render them slower of combustion and are less sensitive to shocks and to heat. They are as a rule less inflammable than guncotton; they contain usually no metallic salts that produce smoke. There are three classes of smokeless powders:

I. Mixtures of nitro-cellulose and nitro-glycerin.

II. Those consisting of nitro-cellulose mainly.

III. Those consisting of the nitro-derivatives of the hydrocarbons.

NITRO-GLYCERIN.

This is a nitric ether of glycerin and not a nitro-compound as its name would suggest. Since glycerin is a tri-atomic alcohol, nitro-glycerin is formed by the replacement of three hydrogen atoms by three nitro-groups,

$$C_3H_5(OH)_3 + 3HNO_3 = C_3H_5(NO_3)_3 + 3H_2O.$$

"The manufacture of nitro-glycerin is guided by the same principles as that of guncotten; the sulphuric acid being used to keep the concentration of the nitric acid up to the proper degree, that is, to take up the water formed during the reaction." In an

additional way, the sulphuric acid helps to precipitate the nitro-glycerin, since nitro-glycerin is soluble in either concentrated nitric acid or concentrated sulphuric acid but not in a mixture of both. In nitration, it is not possible to bring the whole of the nitro-glycerin at once into the acid mixture as in the case of guncotton, because the heat developed in the reaction would raise the temperature dangerously high. On account of the viscosity of the sulphuric acid, we can not pour the mixed acid into the glycerin because a thorough mixing would not take place before the temperature of decomposition of nitro-glycerin was reached. For these reasons, the whole acid mixture is placed in a suitable vessel, and the glycerin is allowed to enter the mixture in small quantities. Nitro-glycerin was invented by Ascanio Sobrero in 1847. The glycerin used is very concentrated, specific gravity 1.26. The mixed acid used in nitration contains about 60 per cent concentrated sulphuric acid and about 40 per cent concentrated nitric acid.

The nitration is carried on in a lead vessel. A thermometer is provided to give constantly the temperature of the mixture. The glycerin is forced in under pressure through a perforated, one turn, coiled tube at the bottom of the lead vessel. The temperature is kept down by a stream of cold compressed air that continually bubbles through the mixture and stirs it. Cold water also circulates around the outside. The temperature is never allowed to go above 20° C. The time of nitration is about 30 minutes.

After nitration, the mixed acid and nitro-glycerin is allowed to run to the separating house where the nitro-glycerin separates from the heavier mixed acid by floating on its surface. Once separated, the nitro-glycerin is allowed to run to another building, the neutralizing house, where the acid that still clings to the nitro-glycerin is neutralized by a sodium carbonate solution. After this neutralization, it is washed thoroughly with water and separated from the water. In this condition it will keep safely for years.

Pure nitro-glycerin is a water-white liquid. Its specific gravity is 1.6. It is soluble in alcohol and in ether. It is almost never used directly, except in torpedoing oil wells when it is made on the spot where it is to be used. Nitro-glycerin is especially important because it is the essential ingredient of dynamite.

Noble first made use of nitro-glycerin in 1864 and he invented dynamite in 1866.

DYNAMITE.

Dynamite is simply some kind of absorbent such as wood pulp or an infusorial earth, saturated with nitro-glycerin. There are two kinds of dynamite:

I. Where the nitro-glycerin is mixed with an inactive substance like kieselguhr. In this case the absorbent is called a "dope."

II. Where the nitro-glycerin is mixed with an active absorbent like ammonium nitrate which is of itself an explosive.

In the common forms of dynamite there are a large number of substances namely:—

(a) Nitro-glycerin,
(b) The absorbent or "dope,"
(c) Ammonium nitrate or sodium nitrate,
(d) A little calcined soda to destroy possible trace of acid,
(e) Vulcanized rosin to allow for the oxygen excess in sodium nitrate or ammonium nitrate.

The rosin is vulcanized to make it granular, the ammonium nitrate is coated with vaseline to reduce the effects of deliquescence. All these substances are incorporated in a special mixing machine and the mixture transferred to paraffin paper shells possessing the familiar form of a stick of dynamite. The detonation of guncotton and of dynamite is best accomplished by a cap containing mercury fulminate, the explosion of which disrupts the molecular structure of the high explosive. If you touch a match to a dry piece of guncotton or to a quantity of nitro-glycerin, it will burn like so much red fire, that is, harmlessly, for this does not detonate it. Detonation then, and not ordinary burning, brings out the highest effect of a so-called high explosive.

In the above paper the writer has drawn many of the facts from the classic work of Guttman, "The Manufacture of Explosives" which is without doubt the most reliable work on the subject.

PROBLEMS THAT ARISE IN THE TEACHING OF ELEMENTARY ALGEBRA IN THE FIRST YEAR HIGH SCHOOL COURSE.*

By Alice M. McKelden, Ph.D.

Philadelphia High School for Girls.

In the words of the German proverb I would say "Aller Anfang ist schwer", and so to the students meeting for the first time, the new concepts found in algebra, the subject will indeed seem difficult unless presented under the guise of old truths previously learned and digested. Accordingly, upon the teacher who first introduces the subject of algebra to the mind, eager and questioning, but so easily confused, lies a great responsibility. If he will present algebra at first as merely an extension of the arithmetic which has already been assimilated, showing in all detail that there is no vital difference between the consideration of a as a number and 5 as a number, between the process of finding the sum of a and b and of 2 and 3, etc.; showing also that powers are only for convenience as 2^3 expresses more conveniently $2\times2\times2$, and so on; the student will soon realize that to work with a, b, or any other letter involves operations and processes no different from those employed in work with 2, 3, or any number.

It takes time, but it seems absolutely necessary that at the beginning, each member of the class be made to see clearly the truth of what I have just outlined. I would emphasize especially the fact that the sum of a and b is $a+b$ always. Only recently I have noticed that there is a tendency throughout the average class to write the product of factors as simple as $(x+m)\ (x+n)$, as $x^2+mnx+mn$; while no mistakes are made when m and n have numerical values. For such reasons as the above, I urge the importance of time spent on the beginning of the subject.

This is just wherein lies the first problem of the high school teacher of elementary algebra; he does not have the pupil when the latter first meets the subject. In the first year high school class are found pupils from many different grammar schools, each taught the fundamental and important truths of algebra in a different manner, each feeling that any variation in the method of teaching that the high school teacher introduces is

*Read before the Association of Mathematics Teachers of the Middle States and Maryland, Dec. 1, 1906.

unnecessary and of no importance. This attitude of the class is very disheartening to the high school teacher who, at a loss to know whether the vital points at the beginning of algebra are clearly and definitely understood, finds it necessary to begin again, going thoroughly over ground already covered once in some manner by the grammar school and so of passing interest to the class that feels that the high school, is teaching nothing new. Is this waste of time and loss of interest necessary? Cannot there be some uniformity in the manner of presentation of the new concepts of algebra so that when the pupil reaches the high school a quick review of essentials is sufficient to bring back the entire subject to his mind and make him ready to comprehend what follows?

Another topic I wish to discuss is in regard to work done by the pupil before entering the high school—that more drill work in fundamental definitions and rules found at the beginning of algebra, be given him. It is absolutely necessary for him to know the definitions of algebra—they give him his subject-matter and in addition train his memory. If he gets this drill in the grammar school where there is more time for frequent repetitions and constant reviews and where his memory is better, in that he is younger, by the time he has reached the high school he can express clearly and concisely what he has learned as the ground work of algebra. As Clarke has said, "The number of new concepts introduced to the mind of the pupil is large; he should have thorough and repeated drill on each before passing to the next. This should not be crowded into the first few weeks of the first high school year."

But when the definitions are given they should be clear, brief in so far as is consistent with clearness, and absolutely correct as far as they go. The pupil should learn them once for all exactly as he is to use them throughout his mathematical course, with no change except that required by generalization. These new concepts are difficult for him to master at best; when once learned, there should be no unlearning of them. This problem has arisen frequently in my teaching, as for example, in teaching that a coefficient is one of the factors of a product, it is at first necessary to efface the definition which has been taught in the grammar school that a coefficient is the number prefixed to a term to denote how many times the term is used. And

as accuracy of definition is essential for clearness of thought, the necessity of thorough drill is perfectly manifest.

So far I have considered only what should be taught the pupil before he enters the high school. With such a foundation as outlined, the review, while essential to impress the new concepts upon his mind emphatically by reiteration and to cast on obscure portions new light reflected from another's manner of presenting the subject, could nevertheless be brief and interesting. At this time Pascal's suggestion that the definition of each term be substituted for the term itself, could be well introduced, for the mind having by previous drill become familiar with the subject-matter, can make use of this knowledge and will not become hopelessly confused in the replacing of one expression by another.

This method leads naturally to generalization which should ever be kept in evidence. It is necessary as early as possible to reach the stage when the pupil depends less and less upon concrete illustrations and can reason more and more clearly from the standpoint of mathematics as a purely abstract science. But though this is the desirable ultimate goal, in the beginning moderation must be used; the goal can only be won by painstaking effort at the first. The pupils that come to the high school are very immature; they cannot grasp general truths at once. So they should be brought to the realization of the nature of generalization as gradually as possible.

I would suggest some such method as the following when a definition, rule or principle is to be learned and applied. Each pupil should be made to illustrate by original examples, first more concrete in form, then more and more general until the definition, rule or principle itself is reached as the limit. For example the definition of a root is to be learned. The illustrations could be given thus: 8 is the product of 3 equal factors 2; so 2 is the cube root of 8; then, generalizing the root but not the power, a^3, where a stands for any number, is the product of 3 equal factors, a, so a is the cube root of a^3; then generalizing still more, a^m where m is any number, is the product of m equal factors a, so a is the mth root of a^m; whence comes the general definition that when any number as a^m is the product of any number, m, equal factors a, one of these equal factors a is the root of the number a^m.

Unfortunately the limitations of time prevent such lengthy examples in general. With rules or principles which are to be applied, sufficient time must be given to cover all possible misunderstandings. Take for example the application of the law of exponents in multiplication and division to examples containing literal exponents. In general, addition or subtraction of the exponents is a simple operation to be performed often indeed mechanically, but addition or subtraction of exponents such as are found in $x^{m+n+2}y^{m+}$ by x^3y^2 presents great difficulties to the average child's mind, and the result $x^{3m+n+2}y^{2m-4}$ or $x^{3m+3n+2}y^{2m-4}$ is as likely to occur as the correct product. Why is it that while he can easily multiply correctly x^2y^4 by x^3y^2 and add $m+n+1$ to 3, when the latter occurs among addition examples, why is it that the combination as given above brings confusion and error to the mind of the pupil? It is because he has not yet learned to apply the rule of addition to examples not occurring rigidly among addition examples, except in the simplest cases; he has not yet learned that what is true of a rule employed in one division of the subject is just as true of that same rule when it is used elsewhere. He has not grasped the general truth.

Again, if you will pardon a personal experience, in leading up to the general rule for the divisibility of $a^n \pm b^n$ by $a \times b$ I explained the rule at length as applied to definite numbers odd or even, in place of n, and the class solved the examples with great enthusiasm. But when once I ventured into realms of generalization, the enthusiasm of the class died away and one of my brightest pupils voiced the opinion of the whole class when she confessed she could not grasp it; she could not understand it. But it was not that they did not understand; they did not know they understood. I found one of their difficulties to be that they thought they were expected to know at a glance whether n were odd or even when only the type a^n+b^n had been given. Such are the perplexities of the youthful mind in grasping these general truths, with which we have all grown so familar. Hence, though it is necessary indeed that the minds of the class grow from the realms of the concrete to the abstract, it is more necessary that they are not forced to grow too quickly.

A good method by means of which each pupil will be enabled to think and reason in terms more and more general, as he becomes more and more proficient is to have in every day's lesson

simple, little questions such as Wentworth uses in his introductory chapter to problems in equations and such as are also found in Hall and Knight's Higher Algebra. Also by leading up to the problems gradually by means of such simple questions as are mentioned above, great facility in the translation of the problems into algebraic language as well as proficiency in their solution is obtained. The necessity for drill of this kind is easily seen. Go into any average class that has been drilled in the fundamental operations as far as factoring and ask the pupils questions like the following:

(1) What must be added to x to make y?

(2) By what must 3 be multiplied to make a?

(3) What dividend gives b as a quotient when $\frac{1}{8}$ is the divisor?

(4) If a be one factor of b, what is the other?

(5) What is the price in cents of 100 oranges when x oranges cost 6 cents?

(6) By how much does x exceed $\frac{1}{3}x - 30$?

(7) What is the cost in dollars of 40 books at x dimes each?

(8) If x men take 5 days to reap a field, how long will one man take?

(9) How many hours will it take to walk x miles at 4 miles an hour?

(10) Out of a purse containing a dollars and b dimes a man spends c cents; express in cents the sum left.

With hardly an exception the pupils will be puzzled by the general form of the questions, which, were numbers substituted for the letters, they would consider trivial and unimportant. Out of a class of 36 girls taking the classical course, almost all very good workers, to whom such a series as part of a test was given, one made 100; 2 made between 90 and 100; 3 between 80 and 90; 6 between 65 and 80; 7 between 50 and 65, and the rest, 17, below 50. That this is not an unusually poor class is evidenced by the fact that only two of the class failed for the quarter, while there were eleven who made between 90 and 100. This experiment only tends to prove the fact that the average high school pupil does not know how to think in general terms, unless he is given careful and conscientious guidance at first, over the difficult places where his logic seems ordained to fail him. And as this is one of the vital reasons for the existence of mathematics—to train the mind in logical,

clear thought and in independence and self-reliance—any means that can be used to help attain the ultimate object should not be despised. Having given in brief suggestions as to the kind of algebraic work and methods to be employed in the grammar school and hints as to the necessity of and the moderation to be used in generalization, I shall now take up in the usual order, a series of problems in teaching that have occurred in the class room and seem to merit discussion.

(1) The process of reasoning leading to the rule for transposition of terms is generally misunderstood by a class which has hitherto known only that to change sides means to change signs and so has mechanically and blindly followed this rule in solving all equations. To the majority the above rule seems as much a self-evident truth as any one of the axioms and they can see no advantage in substituting a longer for a shorter method of solution. Infinite pains must be taken here to show clearly the logical dependence of the rule upon the axiom, not only to prove the rule, but especially to awaken at the very beginning a live interest in logical reasoning together with analytical power. A simple but effective illustration that will appeal to and so aid in the cultivation of the imagination is the comparison of the equation with a balance scale and the necessary means of preserving the balance.

(2) There arises naturally the subject of equations and the means which it offers of solving many practical problems which the student has already met in arithmetic and will meet in physics. But problems of a practical nature are not all that should be offered. There has been a great deal of discussion to the effect of confining all problems to such as will be of future value either in physics or mechanics or in the business of actual life. Why should the more abstract problems be entirely omitted? There is for everyone, whether he be pupil who is going to devote himself hereafter to the study of mathematics or not, pleasure and profit as well that comes from pursuing through its intricate ramifications and finally securing the solution of such a problem as has been designated a mere mathematical puzzle. No comparable exhilaration and triumph comes from the solution of the more simple problems found in arithmetic and physics. I do not mean to say anything against the many advantages gained by the introduction of physical problems in algebra. In addition to their practicality, they familiarize the

pupil with the formulae and terms of science and give them a good drill in solving equations for unknowns represented by letters other than x, y, or z. These physical formulae should by all means be given among the literal equations. Still, though I acknowledge that the problems of daily life and science have their place, nevertheless I advise against making too radical a change and swinging the pendulum to the other extreme.

(3) As an introduction to factoring, the special rules of multiplication and division should be presented to the class exactly as they appear in the type form—*e. g.*—the product of the sum and difference of two numbers is equal to the square of the first minus the square of the second—*not* the difference of their squares. When the rule is learned in that form, the pupil has no difficulty in projecting in his mind the image of the type form and when he has to reverse the process and find the factors he will recognize the case immediately from the type form of the product. In the special rules for division, the sum and difference of two cubes should be treated under the general head of the sum and difference of two odd powers and be governed by the same rules, otherwise the pupil looks upon the cubes as entirely different from other odd powers and the teacher loses the opportunity of giving him first a broad general view of the case before subdividing it into special divisions.

When the subject of factoring is reached, all energy and time should of course be spent upon the ordinary cases which are used most frequently later in fractions, quadratic equations, etc. The class should be thoroughly drilled in these so that finally all factoring can be performed with accuracy and skill. But the examples that do not come under any of the more general heads but require special treatment should be left until the pupil finds a need for them later in his mathematical studies.

The factor theorem as a theorem is a pretty and useful piece of mathematics but entirely too abstract to be understood by immature first year high school pupils. Later in an algebraic review it may and should be introduced but never to the first year pupils.

Because of this omission the method of finding the H. C. F. by division should be taught to enable the pupil to reduce to lowest terms fractions that cannot be easily factored; but not much time should be spent on this interesting bit of algebra, for after the principle is understood, the work amounts to a

drill in division merely. I do not think it should be given the important place in high school algebra it has hitherto occupied. for it should be confined to cases where factoring is seemingly impossible; but it has its uses even in the first year and its principles are easily taught and understood.

(4) The subject of algebraic fractions cannot be studied and learned successfully until the underlying principles of arithmetical fractions are first learned and thoroughly assimilated. Even though in the graded schools the subject has been taught faithfully and conscientiously, it is absolutely necessary to give a comprehensive review of the ground work of fractions in arithmetic before beginning the work in algebraic fractions. Pupils learn mechanically that $\frac{1}{2}=\frac{3}{6}$, etc. They know almost intuitively that they have not multiplied the fraction $\frac{1}{2}$ by 3. But when the fraction $\frac{1}{a}$ has been placed equal to $\frac{b}{ab}$, they will undoubtedly claim that $\frac{1}{a}$ has been multiplied by b. Also they will almost always find the product of $\frac{1}{a}$ by b to be $\frac{b}{ab}$. Mistakes of this kind and mistakes resulting from cancellation of terms are only too frequent. I have found that they can be corrected only by showing how incorrect such methods would be if applied to ordinary arithmetical fractions. So drill in these principles should be given until the pupil understands them thoroughly and can apply them unerringly as well.

The three signs of a fraction have been a source of perplexity to the class as a whole. I shall merely suggest here a plan I have found to be effectual. Regarding $\frac{a}{b}$ as indicating a process in division in which the quotient is to be found by dividing a by b and prefixing the sign according to the law of signs of division we have $+\left(\frac{+a}{+b}\right)=\frac{+a}{b}$; $+\left(\frac{-a}{-b}\right)=\frac{+a}{b}$; $-\left(\frac{-a}{+b}\right)=\frac{+a}{b}$; $-\left(\frac{+a}{-b}\right)=+\frac{a}{b}$. Hence $+\left(\frac{+a}{+b}\right)=+\left(\frac{-a}{-b}\right)=-\left(\frac{-a}{+b}\right)=-\left(\frac{+a}{-b}\right)$ and the principles follow.

(5) In regard to the last part of the algebra taught in the first year, I shall merely suggest, (1) that the omission of cube root entirely is wise on the ground of its infrequent application; (2) that the meaning of zero and negative exponents

be omitted until the class is prepared to consider the theory of exponents (in some of our text-books the proofs leading to $a^0=1$ and $a^{-m}=\frac{1}{a^m}$ are given with rules of division); (3) that in quadratic equations one method only of completing the square be presented, the equations to be solved preferably by factoring or by formula.

In conclusion the number of new concepts and the amount of theory that the class as a whole can comprehend and apply in a given time, and the amount of drill that is sufficient to enable its members so to assimilate the theory as to make it a part of their mental equipment and so grow in the mental strength and independence that comes from the exercise of reasoning, both depend largely upon the kind of school, the size of the classes and their personnel, and the number of hours per week allotted to the teaching of the subject.

It is this intelligent understanding of each pupil's individual needs that the teacher should strive to possess, for with that knowledge he can more surely present the subject in such a manner as to best aid the pupil not merely to grow in knowledge but to cultivate and develop his mental power.

READING NOTICE.

The sixteenth Summer Session of Cornell University will begin July 4, and close August 14, 1907. As last year it will be under the general direction of Professor George P. Bristol, and the plan of the work will be as in former years. Twenty departments of instruction are included, and some of the most noted scholars and most effective teachers of the Cornell faculty will take part in the work. They will be aided by specially competent teachers from other institutions. A new feature next summer will be a course in General Biology, following the New York State Education Department syllabus. The manual training work, both theory and practice, started last year, will be still further developed. That the advantages which Cornell offers with her extensive plant, her fine laboratories and libraries are appreciated, is proven by the attendance last summer of over 600 persons of whom 300 were teachers in colleges and schools of various kinds.

SOME RECENT ADVANCES IN PHYSICAL SCIENCE.*

By Frederick H. Getman, Ph.D.

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Many and various have been the discoveries made in physical science during the last decade and any attempt to review them ever so briefly would consume much more time than is at our disposal. Although physicists have been engaged with research in all of the different branches of physics we find the greatest amount of attention being directed to the study of the passage of electricity through gases and to the allied and equally fascinating phenomena of radioactivity.

To some of these researches I ask your attention, and for my failure to mention much excellent work along these lines I must make lack of time my excuse.

ROENTGEN RAYS.

While the study of the passage of electricity through gases at low pressures dates back to the early work of Harris in 1834 and of Faraday in 1838 it was not until Roentgen's epoch-making discovery of the X-ray in 1895 that high vacua discharge became the subject of almost universal study.

The observation that photographic plates became fogged in the neighborhood of a highly exhausted tube through which electric discharges were passing led Roentgen to investigate the type of radiation which seemed to proceed from the tube. He found that the bombardment of the walls of the tube by the cathode rays produced a form of radiation capable of penetrating many substances which are opaque to light. Aside from their penetrating power the Roentgen or X-rays produce luminescence in barium platino-cyanide and several other salts, this property being made use of in the well known fluoroscope. It was also discovered that the X-ray is capable of discharging an electrified body on an insulated support. The physical nature of the X-ray has been the subject of much experimental work. Since the rays are neither reflected nor refracted and since it is only with great difficulty that they have been made to exhibit slight signs of polarization we would be inconsistent were we to identify them with ordinary light. On the other hand we are not

*Paper read before the Physics section of the Connecticut Association of Classical and High School Teachers, New Haven, Feb. 16, 1907.

justified in considering them as a flight of material particles since they are not deviated by a magnetic or an electric field.

In 1896 Sir George Stokes suggested that the X-rays should be looked upon as single, irregular ether pulses propagated with the speed of light.

J. J. Thomson has shown that by the sudden stoppage of a moving electrified particle, an expanding spherical shell of electromotive force would start and radiate from the particle with the velocity of light. Within the shell electric and magnetic forces exist at right angles to each other and also to the direction of propagation. Stokes has shown that such disturbances would have many of the properties possessed by the X-ray.

According to this theory the character of the ether pulse should be dependent upon the character of the arrest of the electrified particle. In support of this requirement of the theory may be cited the well known fact that the character of the radiation is dependent upon the degree of exhaustion of the tube, the so-called "hard rays" being obtained with high exhaustions.

CATHODE RAYS.

Crookes advanced the idea that the cathode rays consist of a stream of electrified particles and the discovery of Roentgen, together with the conceptions of Stokes as to the physical characteristics of the X-ray, only confirmed this suggestion. It was the natural consequence of Roentgen's discovery that the cathode rays should receive closer attention than ever before and in the course of experimentation M. Perrin gave a direct proof that the cathode rays carry a negative charge. He showed that when the rays within the tube were deflected by a magnet so as to fall within a metallic screen connected with the earth, an insulated metallic cylinder inside the screen exhibited a strong negative electrification and when the rays fell on other parts of the tube the electrometer showed no sign of electrification.

We now turn our attention to the experiments carried out in the Cavendish laboratory of Cambridge University under the skillful direction of J. J. Thomson. He repeated the experiment of Perrin subjecting the cathode rays successively to the action of a magnetic and an electric field. From the results of

this experiment it is possible to calculate the velocity of the cathode particles, to determine the nature of their charge and to measure the ratio of e, the charge carried, to m, the mass of the carrier. The results obtained from this experiment are so important that it seems advisable to outline the method as briefly as possible.

Imagine a single electrified particle to be moving in a rectilinear path with uniform speed v. Let us now apply an electric field of uniform intensity, f, at right angles to the direction in which the particle is moving. The force on the particle is fe and the acceleration, a, at right angles to the initial path is given by $\frac{fe}{m}$ or the particle traces a parabolic orbit. The electric displacement is then $d_e = \frac{1}{2}at^2 = \frac{1}{2}\frac{fe}{m}t^2$.

In the interval of time t the particle traverses a distance $l = vt$; from which we get $t^2 = \frac{l^2}{v^2}$ or $d_e = \frac{1}{2}\frac{fe}{m}\frac{l^2}{v^2}$ . . . . (1).

Equation (1) involves, the electric intensity, the velocity of the particle and the ratio of charge to mass.

We now replace the electric field by the magnetic field of intensity H, also at right angles to the path of the particle. The particle moving with charge e at speed v is equivalent to a current C passing over a path dl or $ev = cdl$.

In this case the force of the particle is Hev and is at right angles to both the magnetic force and the direction of motion. The direction constantly changes similar to the pull on a string by which a stone is whirled. Therefore the expression for centrifugal force, $\frac{mv^2}{r}$ applies and we have $Hev = \frac{mv^2}{r}$ or $r = \frac{mv}{eH}$.

The magnetic deflection is $d_m = \frac{l^2}{2r} = \frac{l^2 H}{2v} \cdot \frac{e}{m}$ . . . . . (2).

Here we have a new relation between v and $\frac{e}{m}$ thus enabling us to calculate both v and $\frac{e}{m}$ in absolute units.

In carrying out the experiment Prof. Thomson applied both electric and magnetic fields simultaneously, so adjusting the lat-

ter that it exactly balanced the former and no deflection took place.

Under these conditions $fe = Hev$ or $v = \frac{f}{H}$ and $\frac{e}{m} = \frac{2vd_m}{l^2H}$.

The results of these experiments show that v may vary considerably, from 2×10^9 to 4×10^9 centimeters per second, while the quantity of $\frac{e}{m}$ remains constant. It has been shown that the ratio $\frac{e}{m}$ is independent of the nature of the gas and of the materials of which the cathode is made, the value of the ratio being about 7.7×10^6.

The passage of one electro-magnetic unit of electricity in electrolysis liberates approximately 10^{-4} grams of hydrogen and the value of $\frac{e}{m}$ is therefore 10^4.

From this we see that the value of e m for the cathode rays is nearly 800 times greater than the corresponding value for the hydrogen ion in electrolysis.

Were it possible to determine the charge carried by the cathode particle it is evident that we could determine its mass. This problem has been successfully solved by Thomson, the method employed and the results obtained being outlined later.

Ionization of Gases.

Under ordinary circumstances air and other gases are very poor conductors. If due precautions are taken to prevent leakage along the supports electrified bodies maintain their charges over considerable periods of time.

C. T. R. Wilson in the construction of the electroscope bearing his name has made use of the remarkable insulating properties of sulphur, and has developed an instrument in which all tendency for leakage along the supports has been removed.

But even here we note a slow but continuous loss of charge which can only be explained on the assumption that air possesses slight conductivity. The hot gases arising from flames have long been known to discharge electrified bodies and attention has already been recalled to the action of Roentgen rays upon a charged electroscope. Ultra-violet light has been found to exert a similar action upon charged bodies and the recently discovered radio-active substances are remarkably efficient in this respect.

It has been shown that gases which have been subjected to the action of any of these agencies do not part immediately with their power of discharging the electroscope but may be blown considerable distances through tubes and still be capable of causing the leaves of the electroscope to collapse. From these and similar experiments we infer that gases undergo a process of ionization resembling that experienced by electrolytes.

It is possible, however, to remove the gaseous ions by contact with solids or liquids or through the action of an electric field. There is also a gradual disappearance of ionization without any of the agencies just mentioned. This last fact has led to the hypothesis that the positive and negative ions recombine under the attractive forces of opposite charges. The conception has been subjected to mathematical treatment and from the experiments of Prof. Rutherford the hypothesis has been confirmed, it having been shown that if the concentration be 10^8 ions per cubic centimeter, half of them recombine in one second.

Conductivity of Gases.

In accordance with Ohm's law the current passing through a gas should be directly proportional to the electro-motive force applied. This point was tested by Thomson and Rutherford by ionizing the air between two parallel metal plates by means of the X-rays. One plate was connected with one pair of quadrants of an electrometer, the other pair being connected with the earth, the second plate was connected with one pole of a battery, the remaining pole being earthed.

With this arrangement of apparatus it was found that for small potential-differences the gas obeys Ohm's law but as the potential-difference increases the current increases more and more slowly. Finally the current becomes constant until the difference in potential is great enough to cause a spark to pass, when it increases at a rate greater than that demanded by Ohm's law. When the current attains to saturation it becomes independent of the intensity of the voltage, a fact which renders the determination of the degree of ionization of a gas a matter of considerable ease. All that is necessary is to assure oneself that the saturation value has been slightly exceeded and then the current can be measured either by the rate of deflection of the electrometer needle or by the rate of collapse of the gold leaves

of an electroscope. This method has been adopted by the Curies and their colleagues in determining the activity of various radio-active preparations. It has been found that the ionization current increases with increase in distance between the plates, a result which is in complete accord with the theory, since the increase in space affords more room for the ionizing agent and thus augments the number of ions.

From the experiments of Rutherford and Zeleny it is possible to calculate the velocities of the individual ions the results obtained by the two workers being in very good agreement. It has been shown that for pressures greater than a small fraction of an atmosphere the speed of an ion varies inversely as the pressure of the gas through which it moves. This statement when compared with the well known fact that the internal friction of a gas is independent of the pressure shows that there is no analogy between the motion of the gaseous ion and the gaseous molecule.

It has been shown that the impact of the cathode particles upon the molecules of a gas is sufficient to cause ionization. If two metal plates be separated by a layer of gas and a difference of potential be set up between them the few ions which are present in the gas are set in motion, the positive ions moving to the negative plate and the negative ions to the positive plate. As the pressure is diminished the longer the free path of an ion becomes before colliding with a molecule of the gas and hence the greater its velocity. When collision does take place the greater the impact and the greater will be the ionization.

If the pressure be sufficiently reduced the result will be that the supply of ions will continually increase and eventually a continuous electric discharge will pass through the exhausted gas. The potential-gradient required to produce ions by collision at atmospheric presure amounts to approximately 30,000 volts per centimeter.

Condensation Nuclei.

Some years ago Aitken observed that dust particles in the air aided the formation of fog. If no dust were present a condition of supersaturation could be reached if the air were subjected to sudden adiabatic expansion.

These early observations of Aitken were extended by C. T. R. Wilson, who pointed out that if the air were rendered dust-free

by preliminary expansion an increase of volume from 1 to 1.38 was necessary to cause the formation of a dense fog or cloud On the other hand, if the air were ionized the cloud formed at an expansion of 1.25. In other words, the gaseous ions can replace the dust particles as condensation nuclei. Some years ago Sir George Stokes investigated mathematically the friction of a sphere moving through a viscous liquid. He pointed out that as a spherical drop falls its velocity increases and at the same time the friction increases until finally a steady state is reached when the force due to the weight of the drop is equal to the friction. Under these conditions the velocity of the drop is uniform and by observing the rate of fall of the drop we can calculate its radius.

Wilson applied this method to the determination of the number of nuclei or ions in the clouds formed in his fog chamber. From the value of the expansion used and the total volume of the fog chamber it is easy to calculate the volume of the water condensed. Dividing the total volume by the volume of each drop we obtain the number of drops and as each ion acts as the nucleus of a drop we know the number of ions. This method was employed by Thomson in determining the number of ions per cubic centimeter of a gas. Knowing their velocity under definite potential and measuring the current through the gas under known potential he was able to calculate e, the ionic charge.

The value obtained for e agrees closely with the corresponding value of e for the hydrogen ion in electrolysis.

We have already seen that the value of $\frac{e}{m}$ for the gaseous ion and for the hydrogen ion in electrolysis are to each other as 800 : 1 and since the charge is the same in each case we are led to the very important conclusion that the gaseous ion is nearly one one-thousandth of the mass of the hydrogen atom.

CORPUSCLES.

Thomson has confirmed his results by studying the ionization produced by ultra-violet light falling on a metal plate in a highly exhausted vessel. By this method he was able to measure e and $\frac{e}{m}$ for the same particle. The agreement between the two methods is surprising, the value of $\frac{e}{m}$ by the first

method being 7.7×10^{9} and by the method just mentioned 7.3×10^{9}.

We are thus forced to the conclusion that the chemical atom is made up of from eight hundred to a thousand smaller particles which Thomson calls corpuscles. Associated with these corpuscles is a negative electric charge which appears to play the part of a true unit of electricity. Although search has been made for it, the corresponding positive corpuscle has never been found, the positive ion thus seeming to possess atomic dimensions.

These facts have been explained on the assumption that the corpuscle represents a unit negative charge of electricity.

Thus an atom with one corpuscle in excess of its normal number possesses a negative charge, while an atom which is deficient by one corpuscle is positively charged.

Since experiments have shown that the mass of the corpuscle is independent of the nature of the gas or of the electrode used in producing it we are led to the further conclusion that all matter is made up of similar ultimate particles.

This belief in the ultimate particle has existed for years largely through man's scientific intuition but today Thomson furnishes us with undeniable evidence of the truth of our long-cherished conception. In 1887 Sir William Crookes wrote: "I venture provisionally to conclude that our so-called elements or simple bodies are, in reality, compound molecules. What existed anterior to our elements, before matter as we now have it, I propose to name Protyle." Thomson's corpuscle seems to fill the requirements of the protyle of Crookes.

The corpuscular theory may be employed to explain why it is that the absorption of cathode rays is proportional to the density of the absorbing substance, while no such relation exists for light. We know that gold, silver, iron and glass, all of them heavy bodies, or paper, cork or water, all light substances, may be either opaque or transparent to light. On the other hand, these substances absorb cathode rays or the radiation from radioactive bodies in direct proportion to their densities.

Until the evolution of the corpuscular theory it was difficult to see how these facts could be explained. Under the present conception of the atom, it is to be looked upon as a miniature solar system in which the corpuscles play the part of satellites to a central nucleus. The inter-corpuscular spaces within the atom

are thus very great in comparison with the dimensions of a single corpuscle so that when the cathode particles bombard a sheet of metal they find their way through the atomic structure.

The absorbing powers must thus be proportional to the density of the absorbing material and also independent of its other properties.

IONIZATION CAUSED BY INCANDESCENCE.

It has been shown that the hot gases from a flame and the air near an incandescent solid will discharge an electrified body. Elster and Geitel have studied the effect produced by a platinum wire as it is gradually heated. At a low red heat it gives off positive ions and then as the wire is heated further, negative ions begin to be emitted until at high temperatures the latter predominate. It has been found that in a vacuum the negative leakage from platinum filaments is very large, amounting in some cases to as much as an ampere per square centimeter. These negative ions are to be looked upon as identical with corpuscles.

Not only do solids emit corpuscles at high temperature but also gases and vapors are capable of giving off a large supply. Arrhenius has pointed out that this class of phenomena has a very important bearing on cosmic processes.

The photosphere of the sun contains carbon heated to an extremely high temperature and thus is capable of emitting corpuscles. This emission of negative electricity will go on until the electrostatic attraction of the residual positive charge is sufficient to bring about a condition of equilibrium.

Any sudden change in temperature would obviously disturb this equilibrium, corpuscles passing either outward or inward as the temperature rises or falls. It is known that when corpuscles pass through the gas with high speed they render it luminous. Arrhenius explains the Aurora Borealis on the supposition that corpuscles from the sun stream through the upper regions of the atmosphere and cause it to become luminous.

METALLIC CONDUCTION.

The phenomena of electrolytic conduction must now be interpreted in terms of the new corpuscular theory.

The cation must consist of an atom of the electrolyte minus one of its corpuscles while the anion must be regarded as an atom of the electrolyte plus its associated corpuscle.

The cation is positive because it has lost one unit of negative electricity. The modern theory of electricity brings to mind the old "single fluid" theory in which the terms positive and negative were used to designate an excess or a deficiency of electricity. In fact it would only be necessary to revise the meaning of the terms positive and negative to make the old conventions fit the new theory.

It has been difficult to explain metallic conduction by means of the phenomena of electrolytic conduction in liquids but in the light of the new corpuscular theory we may form a fairly clear conception of the process.

We imagine the corpuscles to be freely mobile within the substance of the conductor and when a difference in potential is applied there is an inter-atomic exchange of corpuscles and the current flows.

We must look upon a conducting wire as the path along which the free ends of lines of force can move.

The effect of connecting a source of electricity with the ends of the wire is to cause the lines of force to concentrate within the wire thus relieving the stress in the ether.

It is only the negative ends of the lines of force, attached to the corpuscles, that move, the positive ends remaining at rest.

MATTER AND ELECTRICITY.

It was to the genius of Maxwell supplemented by the experimental skill of Hertz that we owe our present knowledge of the intimate relation between light and electricity.

The electro-magnetic theory of light forces us to the consideration of vibrating systems, the frequencies of which are so great that we cannot conceive of the undulations as originating in the vibration of entire atoms.

The complexity of the light emitted by many incandescent elementary substances shows us that the atom must be very complex also. These facts have puzzled many physicists and of the explanations put forward that of Lorentz and Larmor has received greatest attention. They consider the atom as composed of electric units, called electrons, these units moving in closed orbits about a central nucleus. In terms of this theory, light waves originate from an acceleration in the motion of the intra-atomic electrons and as the electrons are isolated electric units it follows that a magnetic field should deflect them in their orbits and thus change the nature of the light emitted. This consequence of the theory of Lorentz and Larmor has been confirmed experimentally by Zeeman, who discovered that the

magnetic field is capable of doubling and tripling spectral lines.

After J. J. Thomson proved the existence of corpuscles they were at once identified with the electrons of Lorentz and Larmor. If we imagine the atom to consist of a congeries of electrons in rapid orbital motion about a central nucleus we are justified in inferring that the stability of such a system is by no means permanent. The acceleration or retardation of the orbital velocities would tend to disturb the stability of the system and disintegration would result.

This conclusion from the theory would lead us to look for a gradual transmutation of the elements.

From the days of the alchemists to the birth of scientific Chemistry the dream of transmuting the baser metals into silver and gold possessed the minds of many experimenters.

Since the time of Lavoisier students of physical science have looked upon the quest as futile and contrary to well established facts. The recent study of radioactive substances, however, has proven beyond question that atomic disintegration is by no means an impossibility. Uranium has come to be looked upon as a patriarch among the elements and its grandchild radium is the father of a family which would confuse any but the specialist to enumerate.

Here again we witness a beautiful experimental confirmation of a mathematical deduction.

Thomson recently has shown that if we imagine the atom to consist of a number of negatively charged particles or electrons placed within a sphere of positive electrification, many of the periodic relations of the elements which were pointed out by Mendelejeff may be deducted. Under the attractive influence of the central positive nucleus and the mutual repulsions of the electrons, different configurations are produced in much the same manner as Mayer's floating magnets can be made to arrange themselves in different patterns according to the number of magnets involved. It is observed that as the number of magnets is increased, patterns of similar form recur and in much the same way Thomson explains the periodicity of properties in Mendelejeff's table.

The recent work of Thomson and Kaufmann gives conclusive evidence that the mass of a body is to be considered as electric inertia or that the most fundamental property of matter becomes a phenomenon of the ether.

These are a few of the more important advances that have been made in physical science within recent times.

THE MATHEMATICS OF ELEMENTARY CHEMISTRY.

By Principal J. McIntosh.

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The discussion of this subject naturally divides itself into three parts.

I. Mathematics. 1st, from an ideal standpoint. 2d, as it is. 3d, as chemistry teachers want it.

II. The work done in Mathematical Chemistry.

III. The results obtained.

Some noted educator has given us the following: "Whatever improves the mental powers, strengthens the judgment, and sharpens the faculties to keener discernment; in fact, whatever trains the energies and capacities, directing them to their true ends, tends to culture in its highest and best sense." Many maintain that mathematics, in its real sense, holds the broadest place in this field, particularly as it strengthens the judgment and sharpens the faculties to keener discernments. Kepler exclaimed, that "the laws of nature are but the mathematical thoughts of God." Maxwell said: "All knowledge is founded on the comparison of one quality with another. Knowledge that is not exact has but little value and frequently is a detriment to its possessor."

This is very different, however, from the mathematics as we know it in the public schools today. The grade teacher complains because the pupils come to her ill-prepared in their arithmetic, likewise the high school teachers and university instructors. It is probably no exaggeration to say that thirty-five per cent of the pupils fail in arithmetic and a similar ratio in algebra and geometry. From this condition it seems that our schools need men and women who know the underlying principles of mathematics and parents who insist that their children shall think on these things and not upon the next social event of the season.

Most pupils find the solving of new problems very difficult and many find it impossible. The best pupils do the work and the poor ones memorize it. This fact is most noticeable in classes in geometry. In the algebra class, the pupils spend entirely too much time looking for the answer. Our leading educators tell us that we learn from the concrete to the abstract, yet, we teach the abstract mathematics first, then later in their

work in physics and chemistry get the concrete. The pupils see little relation between the two and this is a very difficult matter to teach. All teachers, no doubt, have had the experience with students who could not solve for an unknown when it was T, V, or L, but as soon as X was placed for this unknown, they could solve readily.

The old technical grammar was very unpopular. The boys would not study it; now correlation has made English an interesting study. Even so, the English teachers tell us that technical grammar is an absolute necessity to an understanding of the language. Similarly, mathematics is a great aid to the study of science. "It is absolutely necessary to anything more than a superficial knowledge of the subject." The student must learn that the method of solution of a problem is found in the problem itself, when once read and interpreted properly. "Mathematics had its origin in trying to solve practical problems," and it still used by the engineers who are solving the great problems that are benefiting the human race. The chemist is none the less practical than the engineer.

These facts being true, we ask the teachers of mathematics, First, to drill their students upon the correct manipulation of equations, using different letters for the unknowns; Second, to teach ratio, direct and inverse, proportion, percentage and graphs. Nearly all the problems in mathematical chemistry are in the form of equations, and these equations involve either the direct or inverse ratio. The student must know percentage to calculate the percentage, composition of compounds, and graphs for the drawing of curves of solubility, etc.

So much for the value of elementary mathematics and the need of the preparation of the student for the mathematical chemistry. Why? Freer states: "There are two laws that are fundamental throughout chemistry, the qualitative and quantitative relations. One is as important as the other, and should correlate each other." He further states that "An elementary course in chemistry is not to produce a chemist, but to give the beginner some fundamental principles of the science." The California Universities are quite in line with this idea. Stanford favors a thorough knowledge of elementary chemistry, as a preparatory course, while the University of California desires some qualitative analysis in the elementary course, yet, both universities require the solution of many problems to fix the principles.

The student doing university work states that the solution of problems is of invaluable help to him as a preparation for the advanced work.

One of the benefits derived from the meetings of this Association is that its members come together for mutual help and instruction, but the greatest benefit comes about by the writers of the different papers presenting their views upon some particular subject that they have worked out in their own experience, giving the difficulties met, their attempts at mastering them, and the results obtained. With this end in view we come to the second point. The work done in mathematical chemistry.

Knowing that there are from twenty-five to fifty per cent of the class that have forgotten the above points that the mathematics teacher is requested to fix, in the first lessons, we review these terms and explain the new ones that will be used. The pupils must know, in addition to the mathematical terms, the words meter, centimeter, millimeter, gram, cubic centimeter, the relation of one gram to one cubic centimeter, a barometer, how it is used, how to read it, the terms pressure, standard pressure, atmospheric pressure, an atmosphere, volume, thermometer, the two kinds, Centigrade and Fahrenheit, and how to change from one scale to the other. The class is now ready to form experiments one and two of Richardson's Chemistry understandingly. In experiment one, the pupils easily read Boyle's Tube Apparatus and see that as the pressure increases, the volume of the enclosed gas decreases. They then state the law from which they deduce a general expression for the volume V, at pressure P, when the volume v, and pressure p, are known. Their solving of a few problems fixes this law. In experiment two, Charles' Law is developed. They see that the increase in volume per cubic centimeter per one degree centigrade is a constant; that taking the volume at the lowest temperature this constant, in the form of a common fraction, is approximately $\frac{1}{273}$ of the original volume or the increase in volume due to the increase of one degree is $\frac{1}{273}$ of the volume. Hence it follows that the volume at $1^\circ C$ = volume at $0^\circ C.$ + $\frac{1}{273}$ volume at $0^\circ C.$; volume at $t^\circ C$ = volume $0^\circ C.$ + $\frac{t}{273}$ volume at $0^\circ C.$, letting V = volume at $0^\circ C.$; v the volume at $t^\circ C.$ the class derived the formula $V = v\frac{273}{273+t}$ which they interpret as an expression for the volume of gas under

standard temperature. This argument is carried farther showing that the volume at $-1^{\circ}C. = \frac{272}{273}$ of the volume at $0^{\circ}C.$ and at $-273^{\circ}C. = \frac{0}{273}$ of the volume at $0^{\circ}C.$, so if the law held true for low temperature at -273° C. the gas would occupy no volume, and for sake of convenience the point $-273^{\circ}C$ is called the absolute zero. They discover now a new statement for Charles' Law.

Boyle's and Charles' Laws are now combined into one general algebraic formula: $V = \frac{vpT}{Pt}$ where the major letters represent the things that are in the question and the minor letters the things that are given in the problems. Two or three days are given to the solution of problems to fix this formula.

The student, when performing the experiments, determining the percentage of oxygen in potassium chlorate, the equivalent weight of zinc or magnesium, the ratio by weight in which hydrogen and oxygen combined to form water, sees the need of mathematics and mathematical accuracy to get results. He sees that he must weigh accurately and adjust carefully. He sees that any apparatus may be set wrong and read wrong. When he sees that he must get down to bedrock he gets there. It is then that we begin to get results and this kind of work has its effect in close and logical thinking.

After the above experiment such problems as are found in Newell's Experimental Chemistry and those like the following are given: Find from the following data: First, the percentage of oxygen in potassium chlorate. Second, the weight of a liter of oxygen at standard. Third, a number of liters of oxygen at 27° C. 74 cm. pressure that may be obtained from ten grams of potassium chlorate, knowing weight of the test tube, weight of the tube and potassium chlorate, weight after heating, volume of water displaced, temperature, and the reading of the barometer. At this point such terms as chemical reactions, chemical equations, molecule, atom, milecular weight, atomic weight, laws of definite and multiple proportions are explained briefly, just enough for the student to understand what has been taking place in the experiments. From this time on all problems are worked directly from the reaction.

So the work proceeds, performing experiments, discussing the subject matter in the text and solving the problems given at the end of each chapter, through a period of five or six months,

when one month is given over to the discussion of chemical theories and explanation of the phenomena that they have observed. The ground covered in this discussion was well presented last year by a paper* from Mr. Baker of Lowell High School of San Francisco.

A short review is now taken of the problems on reaction and explained from the atomic theory. To Boyle's and Charles' Laws is added the aqueous tension correction. The class is now ready for such problems as the following: The formation of carbon dioxide from Calcium Carbonate and hydrochloric acid is shown from the reaction of $2HCl+CaCO_3=CO_2+CaCl_2+H_2O$. What weight and what volume of carbon dioxide at 27° C. 74 cm. pressure is formed from twenty-five grams of calcium carbonate? How much hydrochloric acid is necessary? How much calcium chloride is formed? Specific gravity of carbon dioxide is twenty-two, aqueous tension at 27° C. is 26.51 mm., combining weight of H=1; Cl=35.5; Ca=40; C=12. O=16. The students must remember the weight of one liter of hydrogen at standard conditions.

Next show that from Avogadro's Law follows the statements that the same ratio exists between the specific gravities of gases as exists between their molecular weights; that the molecular weight of a gas is equal to twice its specific gravity when referred to hydrogen, and 28.88 times its specific gravity when referred to air. Knowing the specific gravity of a gas, its percentage composition, the class readily solves for the molecular weight and chemical formula of a compound, such as the following problem. A compound which analysis shows consists of carbon and oxygen, 27.27 per cent of the former and 72.73 per cent of the latter. The weight of one liter of the gas is 1.97 grams. Find molecular weight and chemical formula.

The Law of Dulong and Pettit is mentioned incidentally in connection with the methods of location of the discovered elements in the Periodic Table. The student sees that the law of Dulong and Pettit only verifies the results for the atomic weights as determined in other ways. But the Periodic Law they recognize as being the most wonderful of all. They read with interest the comparison of the predicted properties and the discovered properties of the new elements and follow carefully the arguments upon the location of Indium in this table. Since the specific heat of

*SCHOOL SCIENCE AND MATHEMATICS, Vol. VI, No. 4, Page 273, April, 1906.

Indium was correctly determined they see that this element has a place in the table.

Problems on specific heat, electrolysis, and those involving Sanford's formula for the combination of Boyle's and Charles' Laws and the Kinetic Gas Theory are left to the class in physics. This completes the work that is done on combination by weight, and next follows combination by volume. The pupils have learned that two volumes of hydrogen and one volume of oxygen have combined to form two volumes of water vapor, that one volume of H and one volume of Cl combined to form two volumes of HCl, so can understand Gay Lussac's Law of simple volume ratio and the numerical proportion. "The number of atoms* contained in a given volume of a gaseous substance bears a simple ratio to the number of atoms contained in the same volume of any other gas." This, with Avogadro's Law, will enable the pupil to understand the reasoning given for the number of atoms in a molecule of H and Cl. All molecular volumes are equal. The half molecular volume of any gas is the volume which is equivalent to the volume of an H atom. If the teacher uses the molecular relation the numbers in the ratio are the coefficient of a compound and one-half the coefficient of an elementary gas, while in the atomic relation the numbers in the ratio are twice the coefficient of the compound and the coefficient of the elementary gas, thus in $2CO+O_2=2CO_2$ the molecular ratio is 2:1 and atomic relation 4:2, then follows a list of problems such as: Three liters of a mixture in equal volumes of $CH_4C_2H_2$ and CO are burned the products being CO_2 and H_2O. How much O is required and how much CO formed?

Summing up, a course in Elementary Mathematical Chemistry should consist of problems to fix Boyle's and Charles' Laws, Gay Lussacs' Gas Volume Law; on reactions, showing combinations by weight, percentage composition, molecular weights, atomic weights, determinations of chemical formulae, drawing of curves of solubility, etc., and study of the Periodic Table. The best lists of problems that I have found are in Newell's Experimental Chemistry and Bradbury's Manual of Chemistry.

The results bear a simple ratio to the student's preparation in algebra. The percentage of those who do satisfactory work of this character is but little less than the percentage of those who do satisfactory work in the other part of the chemistry.†

*"Atoms" as used in this quotation, would be designed "molecules" by chemists of to-day.—Ed.

†Figures taken from classes in Stockton High School.

PLANT PHYSIOLOGY IN SECONDARY SCHOOLS.

By Joseph Y. Bergen,

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A paper on this subject might properly deal both with what is and what should be taught. Adequately to treat the former topic would demand more time and labor in the collection of data than the speaker has been able to command. A word, however, may here be given to the present status of plant physiology in high schools.

I. WHAT IS.

Here and there a school may be found in which the subject of plant physiology receives considerable attention, but in general it is not well taught. The pupil learns incidentally a good deal about the things which plants do but not much about how or why they do them. If a little laboratory work upon germination is done it is only enough to illustrate the fact that seeds sprout and develop into seedlings. The conditions necessary for germination, the wonderful change of the seedling from almost a saprophytic to a photosynthetic mode of nutrition are taken for granted or ignored. No studies are made of the inter-relations of the endosperm (when present) and the embryo or of the mode of development and rate of growth of the latter. All the phenomena of irritability in plants are dismissed with little more than a mere mention, nutritive processes are hastily summarized and reproduction is regarded as of interest mainly as the function which has called into existence showy floral structures that may be "analyzed." All the way through, the pupil is required to do little more with the fundamental affairs of plant life than to read statements about them and re-tell these in his own language. Least of all is he required to vary the conditions of the plant's existence until he has found out for himself the principal factors in some of its life processes and the upper and lower limits of temperature, light, moisture and so on under which it can exist.

In other words, the teaching of plant physiology is in many cases very meager and wholly textural and formal. To discuss the causes for this state of affairs would lead one no little way into the history of botany and of science teaching in general dur-

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ing the nineteenth century. It is to be feared that one reason why the dynamics of the plant world receive such scant attention is because it is more trouble to give instruction on that side of botany than on some others. Teachers have said to me "I do not care to do much physiological experimenting; somehow it seems to me too hard to be sure whether the results are correct or not. Then it is discouraging for the class to have experiments fail." It is needless to ask how one would rate the chemistry or physics teacher who made such a remark. Plant chemistry and plant physics are doubtless in part more difficult subjects than either science in its relation to non-living matter. There is, then, all the more reason for doing elementary laboratory work to illustrate the simpler manifestations of energy in the living plant body. It may be granted that a moderate proportion of one's physiological experiments will usually fail—What of it? The most instructive experiment which I ever performed was a failure. A plant of *Ficus elastica* had been under observation for a week or two in a set of measurements of transpiration. Finally it was watered to the point of filling the pot up to the lid which was cemented to its top. Instead of transpiring more abundantly the plant suddenly ceased to lose water through its leaves. Day after day it was re-weighed with the same result, until a yellowing leaf at once gave the clue to the situation. It was dead, and dead plants do not transpire.

2. WHAT OUGHT TO BE.

No one can lay down a course in plant physiology which the high schools should be expected to follow in detail. Botany in some schools is studied for eighteen or twenty weeks and in others for a year and a half. Its place in the curriculum is anywhere from the first to the last year. These facts alone would make it difficult to prescribe the kind and amount of work that should be done. But there is an additional difficulty which arises from the fact that biological studies are so largely conditioned by the environment. The physiologico-ecological problems of the New England coast would many of them mean little to the St. Louisan and still less to the Arizonian. As the political speaker has a different set of promises for every ward, so the judicious botany teacher will shape his courses somewhat with reference to the natural interests of his pupils. It is, however, possible to lay

down some rules as to what it is best worth while to try to teach and how it may be taught.

There can be no doubt of the supreme importance of the physiological side of botany. After all, structures exist only for the sake of the functions which they can perform and we are doing the beginner in botany a radical injury if we let him for a moment forget this. It is easier to keep a prepared slide than a growing plant, easier to demonstrate starch grains than starch manufacture in the cell, but that does not excuse the teacher for dissipating too much time in histological work. To me at least it seems unlikely that we shall often make the mistake of giving high school beginners too full or too accurate an idea of the processes of plant life. Fortunately there are enough good laboratory manuals to tell the teacher what can be done in this way and how to do it. The office of a paper like the present one is mainly to discuss the relative value of the several departments of plant physiology for secondary school instruction and to set down in orderly fashion some of the principal categories under which the subject should be considered.

In a general way it is evident that we should lay most stress on the processes which are most important in the life of the plant. But some of these such as mitotic division of the nucleus, are far too difficult to be followed in detail by ordinary high school pupils. It therefore becomes necessary to modify our statements and to say that one should teach those topics in plant physiology which are of great intrinsic importance and which are workable under secondary school conditions. Clearly, following this course will throw a good deal of emphasis on the activities of the entire plant body or its organs as wholes rather on intracellular work. It will also lead us as far into physiological ecology as the principals and superintendents will let us go. The fact that public school classes cannot be kept many hours away from the school building precludes a great deal of field work. Still a good many subjects can be dealt with by means of reports on field work done by designated members of the class, supplemented by laboratory studies made by the entire division.

Summing up the subjects in plant physiology which can profitably be handled by a good secondary school class in a well equipped laboratory, they may be grouped somewhat as follows:

1. Growth and differentiation of the plant body, from the seed to the mature plant with seed of its own. Studies of the external developmental changes undergone by the plant.

2. The vegetative work of the plant. Studies of the nutritive activities of plant tissues.

3. Reproduction. Studies particularly of sexual reproduction all the way from the simplest zygospore formation to the fertilization and development of the ovule in seed plants.

4. Responses of the plant to the demands of its environment. Studies of all such manifestations of irritability as help the plant to adjust itself to its conditions of life. Also the investigation of some such plant structures as seem to have been evolved as means of protection against hostile conditions. This may seem much more ecological than physiological study, but after all there is little except the floristic and the geographical side of ecology which is not esentially a part of physiology.

It would be a wearisome and time-consuming labor to enumerate all the studies and experiments which might be undertaken in carrying out the course of plant physiology just outlined. But it may be worth while to suggest a few of the most important topics to be dealt with under each of the four heads above given.

Under the first come studies of germinating seeds, investigating the conditions under which germination is possible and ascertaining the optimum amount of such factors as air, moisture, and temperature. The rate of growth of the organs of the young seedling may be measured and their relative extension in various species compared, with discussion of the differences observed. The development of leaf buds may be followed through one season and the history of branches traced backward through many seasons. The origin and extension of conducting and strengthening tissues in root, stem and leaf may be partially followed. Evolution of flower buds into flowers may at least be outlined.

Under the second head the amount that can be done must depend a good deal on whether or no the class has any knowledge of chemistry. If it has, the whole subject of nutrition may be taken up in an elementary way. This should include studies of the sources of the raw materials of the plant body, of the osmotic activity of cells, of the transference of liquids throughout the plant body, respiration, photosynthesis, and the storage and subsequent utilization of reserve materials.

The treatment of the third general subject, reproduction, need not be discussed in detail. It is perhaps sufficient to say that a considerable series of studies of its simpler forms will greatly

clear up the student's comprehension of what the process really signifies. It is perfectly possible to deal with some of the steps in the evolution of reproductive processes even in courses where not much time is spent upon the study of spore plants. This can only be done by concentrating the attention upon the gametes minimizing the treatment of other stages in the life histories.

Under the fourth head, responses to environment, satisfactory work must, as already suggested, much of it be done in the field. This, however, would in any case need to be largely supplemented by laboratory studies, and some topics can be handled entirely from the laboratory side. A very few of the subjects that may be investigated are the struggle for existence among buds and branches, the influence of varying degrees of illumination on foliage, the hibernacula or the summer resting condition of perennial herbs. Much that is interesting may be learned about the structural and functional variation of xerophytes under widely differing conditions as regards water supply. Heliotropism of stems and leaves and the changes of leaves and flowers from the diurnal to the nocturnal condition and back may be examined in a quantitative way. For the pupils who can do out-of-door work, even with a single flower bed, a large amount of spring study can profitably be devoted to the actual working of floral arrangements for insect pollination.

But it is needless to multiply examples of the many points of view from which the plant may be approached and interrogated as to its life processes. One important suggestion is that every member of the class need not be, I had almost said must not be—given just the same observations to make and the same problems to solve. Much more can be done by allowing some liberty of election, at any rate in field work.

So far I have said next to nothing about plant physiology as exemplified by the lower forms. Of course the activities of the higher plants are so much more varied than those of the thallophytes that the former afford far more material for physiological observations. It would be difficult to put in figures the comparative responsiveness of a *Pleurococcus* cell and a sensitive plant, as they appear to the beginner in plant physiology. And yet the very simplicity of the life of the less differentiated spore plants makes them admirable material for the study of many life processes. Such subjects as osmosis and plasmolysis are nowhere better illustrated than by cells of *Spirogyra*. Ordinary cell di-

vision and multiplication by budding are well shown by *Spirogyra* and *Saccharomyces* respectively.

Various movements such as ciliary action, phototaxis, amoeboid movements and protoplasmic streaming are best shown by certain spores or spore plants. The series of steps in sexual reproduction which culminates in the process as found in seed plants can be traced from its simplest form, as exemplified in *Spirogyra* and the desmids to its penultimate stage in *Selaginella.*

Among the higher spore plants there can be found many remarkable degrees of adaptation to extreme conditions as regards water supply. Most of the so-called water ferns, for example, are true aquatics. The majority of our common ferns are denizens of moist woods. But some ferns, like various species of *Notholaena, Cryptogramma, Polystichum, Cheilantres,* and *Pellaea,* are extreme xerophytes. A few of our ferns are tolerant of full sunlight, many prefer moderate shade and some, such as *Cystopteris fragilis* and *Adiantum Capillus-Veneris,* flourish in the mouths of caverns and rock shelters, where the average illumination is probably much less than five per cent of that of unshaded places.

Dismissing in this rather hasty way the outline of physiological processes to be studied and of material to be employed, there remains for discussion the manner in which the work is to be handled. Here the speaker must confess himself to be at a decided disadvantage. For in nearly twenty-five years of botany teaching it has been his misfortune always to have had to do without any laboratory facilities worthy of the name. There may be other such unfortunates in the audience, teachers who have also been victims of home made apparatus and of the school desk masquerading as a laboratory table. Experiences of this sort lead one to emphasize as indispensable for satisfactory results the use of an adequate, well-stocked laboratory. For physiological work most important requisites are well regulated temperature, sunshine and, (if possible) a small greenhouse or its equivalent. Even a large, heated bay window with waterproof floor and an atmosphere kept thoroughly moist by large exposed surfaces of wet sand or other porous material will answer. It must be kept in mind that in winter the air of a room heated and ventilated in the ordinary manner is practically desert air, capital for decided xerophytes but death to many of the plants best worth studying.

In the way of expensive apparatus the secondary school need

not provide much except compound microscopes, a clinostat and some moderately sensitive balances. Fortunately the temperature relations of plants can be quantitatively studied with a chemical thermometer, the light relations with a watch and bits of sensitized paper and the transpiration rate with a fairly good balance. These are only typical examples of the many cases in which actual research of scientific value can be accomplished in the field of plant physiology with very simple appliances. The golden mean in regard to apparatus is to give the pupil enough to secure good results but not enough to spare him painstaking or to obscure his view of the process under investigation behind too complex appliances for observing it. Probably most high school pupils would not observe as carefully or as long remember their results concerning the growth of internodes, measured by a self-recording auxanometer as they would such values as could be secured by the use of a pair of dividers and a millimeter scale.

It is still to some extent a mooted question whether the pupil should be told beforehand what values he ought in any given experiment to obtain. Some teachers (otherwise sane) insist that it is necessary first to teach the correct results in order that the pupil may not obtain for himself incorrect ones and then remember them forever. To me this fear has always seemed baseless and many experiences have led me to apprehend much more danger from setting the student to work under the influence of preconceived ideas. Many years ago I had charge of the physics instruction in an important fitting school. The text-book in use contained a calculation of the specific heat of lead in which a wrong value was given for this constant. When the class reported their determinations of this specific heat, a large number of the results closely approached the wrong value given in the text-book. Now this sort of thing does not necessarily imply a deliberate falsifying of notes. It often means nothing more than that the student has re-read his record and honestly felt that there must have been some mistake in setting down data. The next step is to revise these so as to eliminate the probable error. Any of us who have had enough laboratory training to have acquired the habit of accepting facts on experimental evidence, without the evidence of some other person to identify them for us as facts, find it hard to realize the state of mind of the pupil. His education may have been largely linguistic and (as has often been said) he knows of no way to find out the truth except to

look first through the rules and then the exceptions of his grammar or its equivalent. Now though the experience of most of us would doubtless lead us to set laboratory work first and textbook statements, with discussion of results afterward, this plan does not preclude assistance from the teacher as the laboratory observations are in progress. It is an indefensible waste of time and of interest in the subject to let a student spend his laboratory period in futile attempts to get things going. If he is using the compound microscope for the first time and sketching mainly air bubbles, if he is trying to plasmolyze a dead *Spirogyra* cell, he should be set right at once. The frequent presence of the teacher at the pupil's elbow, in the laboratory, saves much waste of energy, minimizes the opportunities for copying the results of others, and secures thoroughness. The last point is most essential, for there are few temptations which more frequently beset the beginner in any kind of laboratory study than the tendency to be too easily satisfied with first results. In discussing with pupils the results of observations and experiments on yeast cultures made at home, I have found that immersing a test tube full of the fermenting mixture in boiling water for fifteen minutes was usually reported to have caused increased production of gas. This result was given by the pupils in spite of the written direction to allow the mixture after heating to remain for an hour or more in a warm place. Of course the tube was examined while it was in the boiling water or upon withdrawal from it and not looked at afterward.

A most important practical question that at once confronts the young teacher who is arranging the schedule for his year's work in botany is how to divide the time between laboratory and class room. Doubtless the former should have a good deal more than half of the time, but just how much more is a question to be solved for each case independently. To me it seems that the young and enthusiastic teacher is rather likely to overdo the laboratory side of the instruction. A good deal of experience in summer school teaching has convinced me that there are few cases of congestion more fatal than those of people who have accumulated a large mass of notes on experiments which they have performed in more or less complete ignorance of what they were doing and why they were doing it. They are left in much the same unhappy condition as that of Mr. Alcott when at the close of one of his famous conservations on Emerson and the

Concord transcendentalists he was asked by an alert Chicago board of trade man, "But, Mr. Alcott, what is it all for?" Perhaps as good a rule as any is to discuss laboratory results in the class room as long as they naturally lend themselves to furnish material for interesting recitation. Then new queries may be raised and the class be put in an expectant attitude so that the opportunity to solve the new problems in the laboratory will be cordially welcomed.

In conclusion it may be well to say a word as to the amount of detail and the thoroughness with which the subject of plant physiology can be studied by high school classes. Authors differ most radically in the thoroughness with which they handle the fundamental topics of this subject. In some high school text-books it is relegated to what is virtually an appendix, while in a few it constitutes the leading part of the general treatment of botany. Taking specific examples, one moderately well known book gives no more detailed explanation of the chemistry of photosynthesis than this: "Carbon dioxide taken from the atmosphere is somehow used up in this operation (manufacturing plant food), and the oxygen which is not needed by the plant is given back to be consumed by animals." Another book, rather difficult for high school use, gives about two and one-half pages to the explanation, makes free use of the terms chloroplast and photosynthesis, gives the chemical composition of carbon dioxide and of water and states that photosynthetic work is due to solar energy. A still more striking disparity of treatment can be found in the case of the subject of fertilization in angiosperms. One author gives the topic (not including cross-fertilization) eleven lines without a single cut, while another gives it nine pages with twelve elaborate cuts. The latter author also employs the most modern terminology, calling the pollen grain a *microspore,* the two cells within it resulting from nuclear division a *male gametophyte* the embryo sac a *megaspore,* and the egg apparatus with accessory nuclei a *female gametophyte.* Between such extremes of treatment as those just given there is a wide range of choice for the teacher.

The rigorousness with which the subject of plant physiology should be handled in the high school ought to be just that which will bring in the largest returns of knowledge of the subject and training of the student's powers without overworking him. Any approach to what ordinarily passes for the nature study method of presentation is out of the question. Too often such treatment

in the lower grades has left the pupil saturated with the idea that he has "had" botany, physiology, zoology or what not and therefore quite unwilling to bend his energies toward learning more of it. On the other hand it would be most unfortunate if the subject were attacked in such fashion as to call for more reasoning power than the high school boy or girl has developed and thus become thoroughly repellent by reason of its difficultness. Apparently the very exacting preparation in physics demanded by some college entrance requirements has, with great numbers of students, resulted in leaving memories of the course as one long nightmare. Our plant physiology should be sufficiently exacting to call for thoroughly careful laboratory work and subsequent reading; it should stand for much in the way of developing a scientific habit of mind, but it need not—must not serve to make the plant world odious. Rather should it add greatly to the student's interest and pleasure in the society of his plant neighbors. If we can arouse in our student ever so little of that enthusiasm about the life and behavior of plants which animated such diverse investigators as Sprangel, Delpino and Müller, Humboldt, Grisebach and Schimper, Knight, Darwin, and Sachs, we may feel that our teaching has not been in vain.

FIELD TRIPS IN BOTANY.

By Willard N. Clute,

Joliet, Ill., High School.

It is astonishing, at the present state of botanical teaching, to hear an occasional botanist still objecting to the field trip for High School students. Time was when a field trip meant an ercursion for plants later to be pressed for the herbarium but at that time the study of botany was largely of the kind described as "pulling flowers to pieces in a laboratory." If teachers simply object to the old-fashioned botanical field trip, certainly we may all object with them, but this need not prevent our changing the object of our field trips just as we have changed the subject matter of the course itself.

The fact is, botany is the one science in which the field trip is most necessary, or at any rate most useful. To be sure the pupil can get a pretty thorough idea of form, function and structure from pickled specimens without leaving the laboratory, but unless field trips are taken he entirely misses that most val-

uable part of botanical knowledge embodied in the surroundings in which his specimens grow. Such a pupil can often tell all about *Marchantia* in the laboratory and utterly fail to identify it in the field or he may study a dozen kinds of preserved algae in school and then wonder what the curious green slime is that covers the pool he has to pass on his way home.

To my mind, every field trip made to secure material for study in the laboratory is justified. The teacher can often obtain the same material more expeditiously by himself, but to do so is to deprive the pupil of one of the more interesting phases of the study. I am not sure that an outline is needed for such trips. The pupils should be told what they are to look for, and the teacher may even point out the specimens, but if each pupil is required to collect and preserve his own material for study his knowledge of the plant and its habitat will be assured. And while going for specimens and returning with them the pupil takes in a great deal of botanical information that, though it may not relate to the subject in hand, is likely to be very useful later. Was there ever a teacher that took his classes afield who was not called upon to answer questions about plants not in the regular lesson before the return to school? It is well, of course in subsequent work in the laboratory to require careful accounts of the habitat of each species even if the field outline is used.

In most localities there seems to be no good reason why the pupil should not collect several of the algae studied and if in autumn, several of the mildews, mushrooms and their allies. Mosses of various kinds are nearly always to be found in fruit and liverworts are to be had either out of doors, or in greenhouses throughout the winter. The ferns and pines, also, are better studied for being seen in the field.

Of another type are the collecting trips for buds, roots, stems, leaves and flowers. These trips may well be taken with outlines in hand. The whole study of buds can be made in the field and even the drawings may be completed in the open air. If plenty of growing plants are to be found in the laboratory or greenhouse, the study of leaves need not call the classes afield, but it is difficult to give a thorough understanding of the variations in flowers without recourse to the fields and woods.

Some of these topics readily expand into extensive studies—the ecology of the flower for instance. If it be held that one of the uses of botany is the training of the pupil to observe accur-

ately and to reason correctly, then floral ecology has few if any superiors as a means to this end. Each flower is a new puzzle and requires different treatment for its solution. The shape of petal and sepal, the arrangement of pistils and stamens, the location of the nectar, the way in which the flower faces, and every line, spot and projection in the perianth have a meaning if we choose to investigate them. And equally complex are the questions of how the pollen is transferred, what insects visit the flower, at what time of the day they come, whether they are large or small, etc. It has been my good fortune for some years to see pupils studying these things in the field, even to the making of the permanent drawings there, with an interest and enthusiasm that I am sure could not have been engendered by the same study in the laboratory.

The study of trees, also, offers fine opportunities for training the botanical student in addition to being of practical importance as well. With a key to the trees of a region, such as any teacher can make for himself from the nearest tree-book, the classes may be set to identifying trees for a few weeks in early autumn with the confidence that it will at once enlist the interest of both the pupils and their parents. Drawings of the leaves and fruits may be required to be made in the open air, and such other notes may be taken as may seem best to the teacher. Usually a comparison of the tree studied with any other that may resemble it, notes of the distribution and abundance of each species, etc., are desirable. The method of seed dispersal and the ways in which fruit or seed is modified for the purpose will form an additional study of great value and may be extended to plants other than trees.

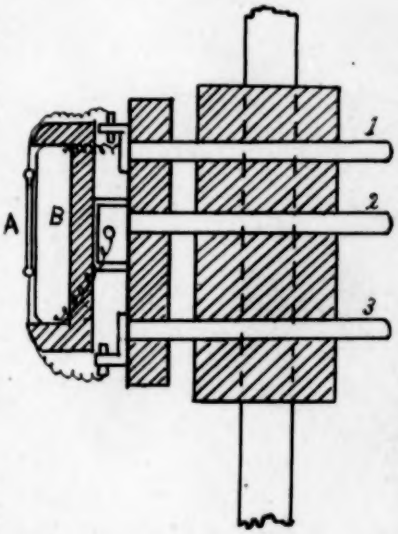
There are few schools so situated as to be unable to make field trips that will benefit and advance the work in botany. The schools of large cities have the parks, conservatories and vacant lots and smaller towns can visit the suburbs in the time allotted to them. In the study of trees it is not necessary to go farther from school than the first unknown tree. Field trips for the collection of specimens for the herbarium have had their day but the new type of field trip, so far from going out of fashion, bids fair to increase in popularity. With the advent of the school garden there seems to be no reason why the greater part of the spring and fall work of the botanical course should not be done in the open air.

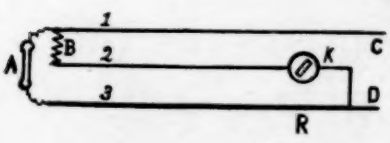
MOUNTING A DEMONSTRATION GALVANOMETER.

By F. R. Gorton,

Michigan State Normal College, Ypsilanti, Michigan.

In the January number of this magazine the author showed a method for mounting a Nernst lamp filament for use in the laboratory. It has proved to be so convenient for many purposes that it may not be amiss to show a special form in which this luminant may be used with the demonstration galvanometer. The chief advantage offered lies in the fact that the brilliancy of the light is such as to make a perfectly visible image on a scale in full daylight. The disadvantage offered in the form previously described is due to the necessity of heating the filament until its conductivity is above a certain value before the current is able to bring it to its maximum brilliancy. In the form shown in Fig. 1 the initial heating of the filament is done by the current of electricity through the heater coils B which soon bring the filament A to the required temperature. The holder, together with the heater coils, filament, and ballast resistance can be procured of electric lighting companies, or the Nernst Lamp Company of Chicago. Figure 1 will sugest a simple mounting for this holder which is made by drilling three holes through a block of hard wood. This same block is provided with a vertical hole for receiving a rod to which it may be clamped at any desired point. A current through 1 and 2 passes through the heater coils B, while that through 1 and 3 goes through the filament A. The former should flow only long enough to start the light, which necessitates a switch between point 2 and the lighting mains.





The connections are shown in Fig 2 in which C and D are the ends to be connected with the mains whose P. D. must be given on ordering the parts. The ballast may be placed anywhere between A and D, as at R, and the key inserted at K. Having the key open, the current may be turned on wherever the connections are made with the lighting circuit; as in a lamp socket, for example. Practically no current will flow until K is closed, when the current is then carried by the coils B which heat the filament. In about 30 seconds the filament will begin to glow with extreme brightness, at which time K should be opened.

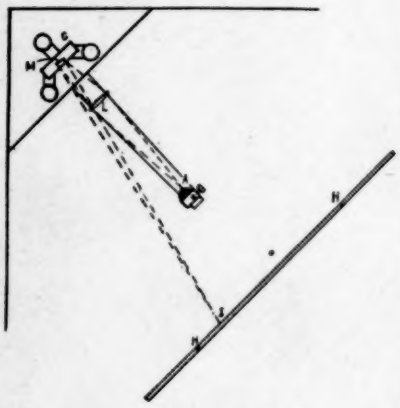
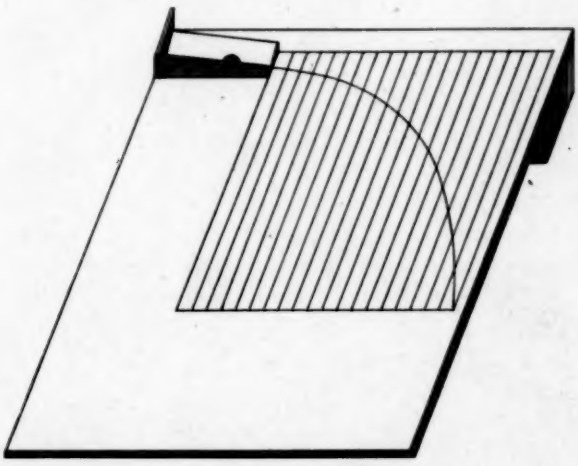


Figure 3 shows a plan for mounting the lecture-room D'Arsonval galvanometer G on the ledge above the blackboard. To the under side of the shelf is attached an arm extending 30 in. from its edge. At the outer end of this arm is a vertical rod on which the lamp holder (Fig. 1) is clamped. At L, 27 in. from the glower of the lamp, is placed a convex lens of 20 in. focal length. About 6 feet from the galvanometer is hung from the ceiling by the hooks HH the scale of ground glass. The parts are so adjusted that the light from the luminant passes through the lens upon the mirror M which reflects the image to the scale at I. Keeping the lamp and lens a little below the perpendicular to the mirror enables the reflected light to pass entirely above the lens to any part of the scale. The key and ballast may be placed at any convenient point on the wall and the terminals of the galvanometer brought over the lecture table at a suitable height where the binding-posts on a small block of wood or porcelain enable the instructor to make connections easily.

LAWS OF FALLING BODIES.

A unique device for illustrating the laws of uniformly accelerated motion, composition of motions, trajectories, etc., has been recently brought out by John C. Packard, Science Master, High School, Brookline, Mass. A steel ball, one inch in diameter, placed at the top of an inclined plane of wood or of plate glass, is



given an initial velocity at right angles to the slope of the plane, by being compelled to roll down an auxiliary incline behind a ledge, and is then allowed to roll down the plane. The path of the ball being the resultant of uniform and uniformly accelerated motion is, of course, a parabola. To secure a tracing of this curve, a piece of co-ordinate paper is secured to the plane, and a piece of soft carbon paper of the same size is placed over it. The ball, in rolling over the transfer sheet, leaves its mark upon the co-ordinate paper. Any number of duplicates can be made by repeating the experiment under precisely similar conditions, or the curve may be varied at will by changing the incline of the principal plane, the auxiliary plane, or both. Measurements made upon the curve thus traced will readily reveal the laws of uniformly accelerated motion, and the fundamental principles underlying the phenomena of falling bodies.

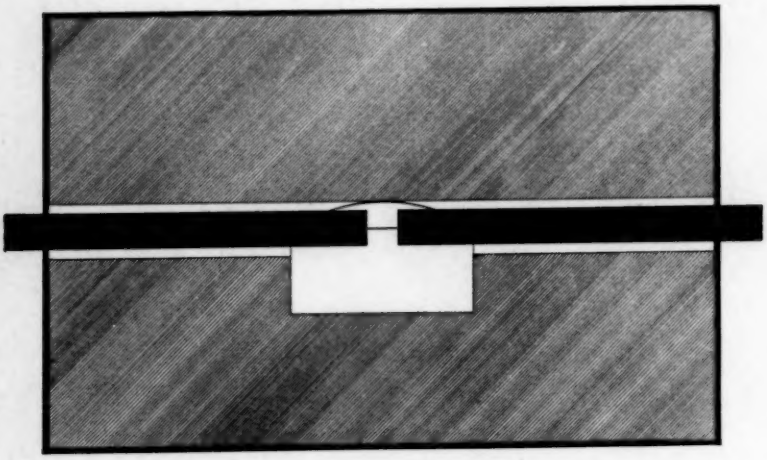
A pendulum attachment, not shown in the illustration, may be used to determine the value of the time interval in seconds, if desired.—*Scientific American.*

SOME PRACTICAL APPLICATIONS OF THE ELECTRIC FURNACE

By Frank G. Taylor,

High School, Oregon, Illinois.

A very simple and serviceable electric furnace can be made with two ordinary fire brick. Along the center line of each, drill a semi-circular groove somewhat larger than the carbons you wish to use. For the lower brick make a cavity in the center about two inches square and one and one-half inches deep. In the center of the other brick make a dome shaped cavity about two inches in diameter. Place discarded electric light carbons in the grove of the lower brick. Fit the upper brick in place and the furnace is ready for the current. (See cut.)



The following are a few very simple but interesting experiments.

1st. Place some small pieces of marble in the cavity of the lower brick. Close the furnace and turn on the current. Light fumes appear around the electrodes. Bring a lighted match to them and they burn with a pale bluish flame, showing the presence of carbon monoxide. The CO is probably formed by the union of the CO_2 with the carbon in the arc, as shown by the ejuations. $CaCo_3 = Ca + CO_2$, $CO_2 + C = 2CO$. In about ten minutes a bright red reflection may be seen on a sheet of paper held near the end of the electrodes, showing the presence of vaporized calcium in the arc. The top may now be removed. An examination shows that the marble has been transformed into quicklime which will slake with great intensity upon the addition of water.

2nd. Repeat the process using soft coal. Soon after the current is turned on dense fumes pour out around the electrodes. Apply a lighted match to the fumes. They burn with a bright flame, showing the presence and source of commercial illuminating gas. After the gas ceases to burn an opening of the furnace reveals that the soft coal has been transformed into a good grade of coke. By using a larger amount of coal and collecting the fumes over water the presence of ammonia can be shown.

3rd. Grind together in a mortar the quicklime and coke that has been formed and repeat the process using this mixture. This time light fumes will be given off which will burn with a pale flame, indicating that carbon monoxide is being formed. After a few minutes an examination of the cavity will show a somewhat crystalline mass between the electrodes. If a portion of this mass is dropped into a test-tube containing water a rapid evolution of gas with the unmistakable odor of acetylene is observed. A lighted match brought to the mouth of the test-tube shows the characteristic acetylene flame. No further evidence is needed to show that the coke and quicklime have united, under the intense heat, to form calcium carbide.

4th. A mixture of sand and coke, with a little salt, will yield bright blue crystals of carborundum, a compound that has never yet been found in Nature. Between the electrodes may also be found silica in the "spun glass" form.

5th. By drawing each end of one of the electrodes across a sheet of paper it will be shown that the hard gritty carbon has been transformed into a soft graphite.

With little care many of the uncommon metals may be reduced from their oxides. Graphite crucibles may be used in this work. Copper and other common metals are easily vaporized and the vapors collected. Space forbids a description of these experiments.

The current to be used may have an almost unlimited range and yet give results. Either direct or alternating current may be used. The most satisfactory being a direct current of low voltage carrying 75 amperes, or more. Very satisfactory results for laboratory use can be obtained by tapping an ordinary incandescent light circuit carrying 110 volts and from 15 to 20 amperes. If an incandescent circuit is tapped care should be taken to use a rheostat to prevent the burning out of fuses.

If the bricks do not fit closely together cover the lower brick with a thin layer of powdered air-slaked lime. In this way all light can be kept in the interior, except along the electrodes. This space should be left open for the escape of gases.

ON SOME OF THE SYMBOLS OF ELEMENTARY MATHEMATICS.

By G. A. Miller,

University of Illinois.

The symbols $+$, $-$, $=$ for plus, minus, and equals respectively are a part of the universal mathematical language. Not only do they have the same meaning throughout the civilized world, but they are also the only symbols in common use to convey the ideas for which they stand. The symbol $\times$ for multiplied by is also in universal use, but it is not the only symbol in common use to express this concept as the period is very frequently used to convey the same thought.

The position of the latter symbol in mathematical notation is far from an ideal one. It has two meanings, being used both for a decimal point and to indicate multiplication. When it is used to represent either of these ideas its position is not fixed, since the English generally write it before the middle of a figure to represent a decimal point and near the bottom to represent multiplication, while in America the reverse is commonly done. Moreover, it is not the only symbol that is commonly used as a decimal point, since the French, German and Italians use the comma to represent this concept. In fact, in earlier times the English generally employed the comma for the same purpose.

While the uses of the period do not exhibit the worst side of the notation in elementary mathematics, yet they are sufficiently objectionable to invite discussion with a view to improvement. If a symbol has two very distinct meanings in the same subject, if people using the same language employ different methods to distinguish between these meanings, and if each of its meanings is shared with another symbol which is in more general use, there seems to be considerable reason for inquiry into possible improvement, especially since this symbol is met so early in the student's career. It should not be inferred that the given methods of using the period as a symbol are without exceptions. In Williamson's Differential Calculus, for instance, the decimal point is written in exactly the same way as the symbol for multiplication, while in Carr's Synopsis of elementary results in pure mathematics the decimal point is sometimes used as in America, but more generally according to the English custom.

As the comma was in general use as a decimal point long before the period[1] and as it is now used for this purpose by a majority of the leading mathematicians, it would appear that the English speaking people had considerable reason for considering the desirability of adopting the comma as the decimal point. In fact, this would only be a re-adoption since the early English writers such as Briggs were among the earliest to employ the comma as a decimal point. Briggs used it in this way in his table of logarithms in 1624, while the first known instance of its use is in the Italian trigonometry of Pitiscus of 1608.

The common symbols for division present a slightly better situation than those for multiplication. The oldest of these is the line between two numbers written one above the other. This symbol is in universal use and has only one meaning in the elementary mathematics at the present time. The other symbols in common use to represent division are $\div$ and : The former of these has also the ideal properties that it stands for only one concept in modern elementary literature and that it is used extensively. The latter, however, does not have the first of these two properties as it is sometimes used to represent a ratio between two numbers of the same denomination and at other times to represent ordinary division. It is true that the ratio between two abstract numbers is identical with division and hence there is no theoretical objection to the use of the same symbol to represent division of abstract numbers and the ratio betwen two denominate numbers. The symbol : is used in this way by some of the best writers.

While there are strong reasons in favor of the use of the symbol : for division in elementary text-books in view of the extensive use of this symbol in European modern mathematical literature, yet the arguments against its use are so serious that Tannery and Molk suggest that the symbol should only be used to represent a ratio, in their excellent article on the fundamental principles of arithmetic published in volume 1 of the *Encyclopedie des Sciences Mathematiques*, 1904, page 44. It is extremely important that a student should realize that we may speak of the ratio of two things when division would have no meaning, and, vice versa, we may be able to divide when there is no ratio between the dividend and the divisor. Since division and ratio may be so distinct it is a question whether the same

[1] Tropfke, Geschichte der Elementar-Mathematik, 1902, vol. 2, p. 158.

symbol should be used to represent these two concepts even if this can be done logically within the proper limits.[2]

The symbol $\backsimeq$ is very extensively used in elementary geometry to denote equivalent to. As it is used very little outside of the elementary text-books and is difficult to make, it seems very desirable that its use as well as the use of the term for which it stands should not be continued. The term equal and the symbol $=$ should be used in its place as is already done in some of the best text-books. On the other hand the term congruent, and the extensively used symbol $\cong$ should be employed in all text-books on elementary geometry.

It seems unfortunate that this symbol, introduced by Leibnitz with the present meaning, should have two different forms, viz.. $\cong$ and $\eqsim$. In fact the upper part of this symbol $\sim$ which indicates similarity is also written in the form $\backsim$. Both of these forms are very old and were used during the latter part of the seventeenth century to represent equality.[3] Some authors seem inclined to regard them as two distinct symbols but they are so nearly alike that they are very apt to be confused and the mathematical notation should be chosen with a view to avoid all possible sources of errors.

The symbol $\sim$ is extensively used to represent many different concepts in mathematics. For instance, it is used to represent the difference between two numbers without any reference to the relative values of the numbers. Webster's dictionary defines the symbol in this way, while the Century dictionary says it signifies "is proportional to." It is extensively used in the theory of aggregates to represent equivalence, and in Pierpont's recent york "The theory of functions of a real variable" it is used to represent the same order of infinite. Its use in group theory, in representing approximate values, and in the theory of infinite series are well known.[4]

Although $\sim$ is used to represent so many different concepts, yet it appears to us desirable that it should be universally used in elementary geimetry to represent similarity—the meaning

2 The symbol : was used by Oughtred to represent a ratio at least as early as 1657; Beman, L'Intermediaire, vol. 9, (1902) p. 229; as a symbol of division it was employed by Leibniz in 1684.

3 Indetermediaire des Mathematiciens, vol. 2, (1895) p. 1.1 and vol. 4, (1897) p. 60.

4 Sander's in his Plane and Solid Geometry, 1903, p. 14 uses $\sim$ to represent is (or aret measured by, and Dupuis' excellent Elementary Synthetic Geometry uses $\eqsim$ to represen) similarity.

which Leibnitz assigned to it—even if such good works as Henrici und Treutlein, "Lehrbuch der Elementar-Geometrie," 1897, and Beman and Smith, "Plane and Solid Geometry," 1895, use $\backsim$ to represent this concept. As one of the latter authors uses $\sim$ to represent similarity in his well known work, "The elementary teaching of mathematics," it appears that the latter of the two geometries mentioned above does not express a strong preference in favor of the symbol $\backsim$. Among the most recent text-books which employ $\sim$ for similarity we may mention Bush and Clarke, "The Elements of Geometry," 1905, and Halsted, "Rational Geometry," 1904.

The symbol $\odot$ which stands for circle has two very distinct meanings in elementary mathematics just as the term circle itself has. Some authors use it for area, while others use it to represent the curve which encloses this area. As the latter is the more common meaning in mathematical literature it is to be hoped that this use will become universal and that the term circumference will soon find no place in elementary text-books. One of the most grotesque types of mathematical symbols is represented by $\sin^{-1}x$ for the angle whose sine is x. While $\sin^a x$ means the a power of $\sin x$ for every value of a which differs from unity, it assumes an entirely different meaning for this special value of a. Various other symbols have been employed to represent this concept. One of the most desirable is $\sin \overset{\frown}{x}$ although this is not as commonly used as arc sin a introduced by Euler in 1737.

The main object of this paper is to call attention to several points with respect to symbols in very common use at the present time without entering upon the history of the ordinary symbols. The latter can be gathered with a fair degree of completeness from the histories of mathematics which are fortunately becoming more common. Teachers and students who use only a few books are apt to conclude that the symbols which they meet are the only ones in common use for these ideas. It is hoped that the present note will inspire caution and will aid to bring about a better condition in the course of time. It has contact with the "Elementary Notes" by Professor Oliver, published in Annals of Mathematics, Vol. 4 (1888), p. 186. As mathematics is preëminently cosmopolitan and eternal it is very important that its symbols should be world symbols. All national distinctions along this line should be obliterated as rapidly as possible.

The main points which the preceding arguments tend to establish may be expressed as follows: The decimal period should be replaced by the decimal comma. The term circle and the symbol ⊙ should be used exclusively to represent the curve, similarity should be represented by ~ and if the symbol ∽ is used it should represent the same thing as ~ the symbol ⌯ and the term equivalent should be abolished from elementary geometry; such symbols as $\sin^{-1}x$ should be replaced by arc sin x or by $\widehat{\sin x}$, and the symbol : should not be defined to indicate division in general, but only to express the ratio.

METROLOGY NOTES.

Great Firm Adopts Metric System.

The Birmingham, England, firm of Kynochs, Ltd., which makes all sorts of goods from gunpowder to candles and soap, is introducing the metric system, in place of the old English, into its extensive manufacturing works. After a preparation of some two or three months, the change was effected in January of this year. Manufacturers who hesitate about the utility of such a change, the cost, or the great saving, should read the statements of Arthur Chamberlain, Chairman of Kynochs: He says, in part: "The metric system has been made legal, but permissive, and it has been expected that our Parliament would make it compulsory, giving two or three years of grace, at the end of which time only metric weights and measures would be legal. But Parliament continues to do nothing, and refuses to take the most simple and most valuable step that could be taken for the benefit of our commerce. * * * The matter became imperative with us because of the enormous mass of figures we have to deal with in our cost office, and we came to the conclusion that we would not wait any longer. * * * We have prepared tables to introduce the metric system everywhere throughout the works, and we have arranged to translate our results into English weights and measures for the benefit of the benighted English. * * * All our catalogues will be printed in the metric system, but for home use we may still translate them into English."

Mr. Chamberlain speaks in no uncertain terms concerning foreign commerce: "The English trade suffers immensely more in its foreign business from its weights and measures and its pounds, shillings and pence, than it does from the language. It is much easier for a foreigner with a small acquaintance with our language to understand our catalogues in English than it is to deal with pages of sizes and weights. Buyers are deterred ten times more by this confusion than by reason of the catalogues being printed in English."

Of the trouble and expense of changing from old to new: "A business man who objects to taking the trouble involved in improving his system had better retire at once. There is no room today for business men

who are not capable of taking trouble, and, as a matter of fact, the trouble involved in the preliminary change will not represent a hundredth part of the trouble we continually suffer from under the old confused system. Compared with the size of our works, and the magnitude of our transactions, the expense will be quite unimportant, and in any event it will repay itself in the first year." R. P. W.

Decimals or Duo-decimals? The late Mr. Herbert Spencer was opposed to the introduction of the metric system, and his chief reason was a preference for a duo-decimal system.

Feeling that they can safely follow so eminent a thinker, some people are content to echo his conclusions without considering what they involve practically. In protesting against the metric system, because of the inconvenience it would cause, they forget that a still greater inconvenience would be caused by the change Herbert Spencer would have preferred.

To show what an impossible project the adoption of a fresh system of notation would be a duo-decimal multiplication table is reproduced below, adopting T as the new symbol for the old number ten, and E as the new symbol for the old number eleven.

The multiplication table in the scale of 12. (New digits, 10 = T, 11 = E.)

2	×	1	=	2	3	×	1	=	3	4	×	1	=	4	5	×	1	=	5
2	×	2	=	4	3	×	2	=	6	4	×	2	=	8	5	×	2	=	T
2	×	3	=	6	3	×	3	=	9	4	×	3	=	10	5	×	3	=	13
2	×	4	=	8	3	×	4	=	10	4	×	4	=	14	5	×	4	=	18
2	×	5	=	T	3	×	5	=	13	4	×	5	=	18	5	×	5	=	21
2	×	6	=	10	3	×	6	=	16	4	×	6	=	20	5	×	6	=	26
2	×	7	=	12	3	×	7	=	19	4	×	7	=	24	5	×	7	=	2E
2	×	8	=	14	3	×	8	=	20	4	×	8	=	28	5	×	8	=	34
2	×	9	=	16	3	×	9	=	23	4	×	9	=	30	5	×	9	=	39
2	×	T	=	18	3	×	T	=	26	4	×	T	=	34	5	×	T	=	42
2	×	E	=	1T	3	×	E	=	29	4	×	E	=	38	5	×	E	=	47
2	×	10	=	20	3	×	10	=	30	4	×	10	=	40	5	×	10	=	50

6	×	1	=	6	7	×	1	=	7	8	×	1	=	8	9	×	1	=	9
6	×	2	=	10	7	×	2	=	12	8	×	2	=	14	9	×	2	=	16
6	×	3	=	16	7	×	3	=	19	8	×	3	=	20	9	×	3	=	23
6	×	4	=	20	7	×	4	=	24	8	×	4	=	28	9	×	4	=	30
6	×	5	=	26	7	×	5	=	2E	8	×	5	=	34	9	×	5	=	39
6	×	6	=	30	7	×	6	=	36	8	×	6	=	40	9	×	6	=	46
6	×	7	=	36	7	×	7	=	41	8	×	7	=	48	9	×	7	=	53
6	×	8	=	40	7	×	8	=	48	8	×	8	=	54	9	×	8	=	60
6	×	9	=	46	7	×	9	=	53	8	×	9	=	60	9	×	9	=	69
6	×	T	=	50	7	×	T	=	5T	8	×	T	=	68	9	×	T	=	76
6	×	E	=	56	7	×	E	=	65	8	×	E	=	74	9	×	E	=	83
6	×	10	=	60	7	×	10	=	70	8	×	10	=	80	9	×	10	=	90

T	× 1	= T	E	× 1	= E	10	× 1	= 10
T	× 2	= 18	E	× 2	= 1T	10	× 2	= 20
T	× 3	= 26	E	× 3	= 29	10	× 3	= 30
T	× 4	= 34	E	× 4	= 38	10	× 4	= 40
T	× 5	= 42	E	× 5	= 47	10	× 5	= 50
T	× 6	= 50	E	× 6	= 56	10	× 6	= 60
T	× 7	= 5T	E	× 7	= 65	10	× 7	= 70
T	× 8	= 68	E	× 8	= 74	10	× 8	= 80
T	× 9	= 76	E	× 9	= 83	10	× 9	= 90
T	× T	= 84	E	× T	= 92	10	× T	= T0
T	× E	= 92	E	× E	= T1	10	× E	= E0
T	× 10	= T0	E	× 10	= E0	10	× 10	= 100

These tables prove that it would be absolutely impossible for this or any nation to adopt a duo-decimal system, unless all other nations adopted it also, and that all opposition to the Metric System, based on a preference of Spencer's ideal system, must be dismissed.—*Decimal Association.*

PRODUCTION OF GAS, COKE, TAR, AND AMMONIA.

A report on the production of gas, coke, tar, and ammonia at gas works and in retort coke ovens during 1905 has been prepared by Mr. Edward W. Parker of the United States Geological Survey and is now ready for distribution. It is supplementary, in a measure, to the reports on the production of coal and the manufacture of coke, and is made in response to a demand from producers of gas and coke and the by-products of tar and ammonia, for statistical information on these subjects.

The present report includes, in addition to the statistics of the production of gas, coke, tar, and ammonia at gas works and in by-product coke ovens, a statement of the production of the quantity of gas and tar produced at water-gas works using crude oil for enriching purposes. These statistics have not been considered in any of the preceding reports. At some of the gas houses oil is used with coal in the production of gas, but the entire production is included in the statistics of coal gas.

The total quantities of these products in 1905 was 40,454,215,132 cubic feet of gas (not including that lost or wasted), 5,751,378 short tons of coke, 80,022,043 gallons of tar, 46,986,268 gallons of ammonia liquor (equivalent to 22,455,857 pounds of anhydrous ammonia), and 38,663,682 pounds of ammonia sulphate, against 34,814,991,273 cubic feet of gas, 4,716,049 short tons of coke, 69,498,085 gallons of tar, 52,220,484 gallons of ammonia liquor (equivalent to 19,750,032 pounds of anhydrous ammonia), and 28,225,210 pounds of ammonia sulphate in 1904. The total value of all these products in 1905 was $56,684,972 against $51,157,736 in 1904.

PROBLEM DEPARTMENT.

IRA M. DELONG,

University of Colorado, Boulder, Colo.

Readers of the Magazine are invited to send solutions of the problems in this department and also to propose problems in which they are interested. Problems and solutions will be duly credited to their authors. Address all communications to Ira M. DeLong, Boulder, Colo.

53. *Proposed by G. E. Ripley, M.S., Valley City, N. D.*

Prove that

$$\sqrt[3]{6+\sqrt{\tfrac{980}{27}}}+\sqrt[3]{6-\sqrt{\tfrac{980}{27}}}=2.$$

I. *Solution by I. L. Winckler, Cleveland, Ohio.*

Let $\sqrt[3]{6+\sqrt{\frac{980}{27}}}=x+\sqrt{y}$, $\sqrt[3]{6-\sqrt{\frac{980}{27}}}=x-\sqrt{y}$. Multiplying, we get $x^3-y=-\frac{2}{3}$ . . . .(1). Cubing and adding, $x^3+3xy=6$ . . . .(2). From (1) and (2), $4x^3+2x-6=0$. The real root of this is $x=1$, hence $y=\frac{5}{3}$. Therefore

$$\sqrt[3]{6+\sqrt{\tfrac{980}{27}}}=1+\sqrt{\tfrac{5}{3}},\quad \sqrt[3]{6-\sqrt{\tfrac{980}{27}}}=1-\sqrt{\tfrac{5}{3}}.$$

II. *Solution by E. Kesner, Salida, Colo.*

Let $\sqrt[3]{6+\sqrt{\frac{980}{27}}}=a$, $\sqrt[3]{6-\sqrt{\frac{980}{27}}}=b$, and $a+b=x$. By cubing $a^3+b^3+3ab(a+b)=x^3$. By substituting and simplifying, $x^3+2x-12=0$. Hence the real value of x is 2.

GEOMETRY.

54. *Proposed by I. L. Winckler, Cleveland, Ohio.*

Describe a circumference which bisects three given circumferences. (From Chauvenet's Geometry.)

I. *Soluion by E. L. Brown, M.A., Denver, Colo.*

Let A, B, C be the centers of the given circles, r_1, r_2, r_3 their radii. Let O be the center, R the radius of the required circle. Draw OM perpendicular to AB, ON perpendicular to BC.

$\overline{AM}^2=\overline{AO}^2-\overline{OM}^2=R^2-r_1^2-\overline{OM}^2$ . . . . .(1). $\overline{MB}^2=\overline{BO}^2-\overline{OM}^2=R^2-r_2^2-\overline{OM}^2$ . . . . .(2). $\therefore \overline{AM}^2-\overline{MB}^2=r_2^2-r_1^2$ . . . . .(3). Similarly, $\overline{BN}^2-\overline{NC}^2=r_3^2-r_2^2$ . . . . .(4). (3) and (4) determine points M and N, and hence point O. Having r and AO, we easily determine R.

II. *Solution by T. M. Blakslee, Ph.D., Ames, Ia.*

Using the theorem*: The locus of the center of a circle bisecting two fixed circles is a ray perpendicular to their line of centers, and knowing one of these circles, that about the isosceles trapezoid whose parallel sides are the diameters perpendicular to the line of centers, we can draw these loci for the circles taken two and two. Their point of concurrence is the center of the required circle. Join this point with the center of either of the given circles. The ends of the diameter perpendicular to the last line drawn are on the required circumference. Knowing the center and a point on the circumference the circle is easily drawn.

55. *Proposed by E. L. Brown, M.A., Denver, Colo.*

Divide a given triangle into two equivalent parts by a line perpendicular to one of the sides.

Solution by A. R. Maxson, M.A., Columbia University, N. Y.

This is merely a special case of the problem to divide a given triangle ABC into two parts having a ratio $m : n$ by a line perpendicular to one of the sides.

Take E on AB such that AE: EB $= m : n$. Join EC and draw HC perpendicular to AB.

Triangle AEC: triangle EBC $=$ AE: EB $= m : n$. Take AF a mean proportional between AE and AH and draw FD perpendicular to AB. FD is the line required, for we have
area AFD: area AHC $=$ $AF^2 : AH^2 = AE \cdot AH : AH^2 = AE : AH =$ area AEC: area AHC. Therefore AFD $=$ AEC and EBC $=$ FBCD. It follows from our first relation that AFD: FBCD $= m : n$.

To divide ABC into two equivalent parts take E the mid-point of AB.

APPLIED MATHEMATICS.

56. *Proposed by W. E. Tower, Englewood High School, Chicago, Ill.*

A sphere is hung from a hook in a vertical wall by a string equal in length to the radius. Find the inclination of the string, its tension, and the pressure on the wall if the sphere weighs 10 lbs.

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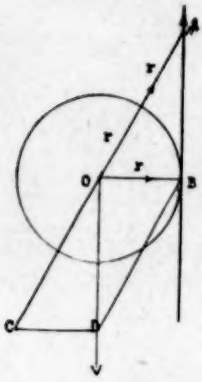
*To prove this theorem: Let O,O′, r,r' be the centers and radii of two given circles and GH, G′H′ diameter perpendicular to OO′. Since GG′ HH′ is an isosceles trapezoid, a circle can be circumscribed about it. Its center C is in line of centers. Through C draw a ray perpendicular to the line of centers. Every point in this ray is the center of a circle bisecting the given circles. For consider a point P such that CP$=b$ and let CH$=$CH′ $=a$. Join P with O and O′ and draw the diameters L,K and L′K′ perpendicular to these. By the Pythagorean theorem

$$CO = \sqrt{a^2 - r^2},\ CO' = \sqrt{a^2 - r'^2},\ PO = \sqrt{a^2 + b^2 - r^2},$$

$$PO' = \sqrt{a^2 + b^2 - r'^2},\ PK = PL = \sqrt{a^2 + b^2},\ PK' = PL' = \sqrt{a^2 + b^2}.$$

Hence the circle with P as center and PK as radius bisects the two given circles.

Solution by Geo. J. Balzer, Milwaukee, Wis.



Let r be the radius of the sphere. Then the distance from hook to center of ball is $(2r)$.

$\text{Sin}OAB = r/2r = 1/2$ and therefore angle $OAB = 30°$.

Resolve the weight of 10 lbs. into 2 components, one making an angle of 30° with the line of direction of the weight, the other making an angle of 90° with the line of direction of the weight.

$OC = 10/\text{cos}COD = 10/.866 = 11.55.$

The tension in the string $= 11.55.$

$OB = BD\text{sin}BDO = 5.77.$

The pressure against the wall $= 5.77$ lbs.

MISCELLANEOUS.

57. *Proposed by H. C. Whitaker, Ph.D., Philadelphia, Pa.*

A square contains just 2 acres of ground. A cow fastened to a stake in the middle of one side is allowed to graze one acre inside the square. How long is the rope in feet?

Solution by proposer.

Let the side of the square be donated by a; the angle of the sector by $2x$. The area grazed over consists of two triangles whose combined area is $\frac{1}{4}a^2\cot x$ and of a sector whose area is $\frac{1}{4}a^2x\csc^2 x$. Equating the sum of these to $\frac{1}{2}a^2$ we find by trial that $x = 59° 5' 3''$ and the length of the rope is 172.024 feet.

CREDIT FOR SOLUTIONS RECEIVED.

Algebra 36. R. Boyle.

Algebra 48. W, T. Brewer, H. C. Whitaker, A. B. Robertson, G. F. McAllister, W. L. Malone, Herman H. Wright.

One incorrect solution was received.

Algebra 53. W. T. Brewer, W. L. Malone, E. Kesner, T. M. Blakslee, Mabel R. Bemway, Louis Lindsey, Ira S. Condit, E. L. Brown, E. H. Myers, Walter H. Wood, A. J. Wile, H. E. Trefethen, I. L. Winckler, John P. Clark.

Geometry 49. H. C. Whitaker.

Geometry 50. H. C. Whitaker.

Geometry 54. H. E. Trefethen, A. R. Maxson, E. L. Brown, T. M. Blakslee, I. L. Winckler, R. T. Schoonmaker.

Geometry 55. T. M. Blakslee, A. R. Maxson, E. L. Brown (two solutions), H. E. Trefethen, E. H. Myers, J. Alexander Clarke, G. G. Brower, C. E. Wheeler, J. L. Riley, P. R. Johnson (two solutions), J. F. West, I. L. Winckler, A. J. Wile, Herman H. Wright, E. Kesner, Roy Walter, R. T. Schoonmaker.

Applied Mathematics 52. H. C. Whitaker.

Applied Mathematics 56. E. L. Brown, G. J. Balzer, T. M. Blakslee, H. E. Trefethen, W. L. Malone, Herman H. Wright.

Miscellaneous 57. H. C. Whitaker, T. M. Blakslee, E. L. Brown, H. E. Trefethen, R. Boyle.

Total number of solutions, 61.

PROBLEMS FOR SOLUTION.

ALGEBRA.

62. *Proposed by W. T. Brewer, Quincy, Ill.*

Solve $x^{\frac{1}{2}} y^{\frac{1}{2}} + x^{\frac{1}{2}} y^{\frac{3}{2}} = 132 \ldots .(1).$

$$\frac{xy + 1}{x^{\frac{1}{2}} y^{\frac{1}{2}}} = \frac{33}{8} \ldots .(2).$$

63. *Proposed by I. L. Winckler, Cleveland, Ohio.*

A stone is dropped into a well, and after 3 seconds the sound of the splash is heard. Find the depth to the surface of the water, the velocity of sound being 1127 feet per second.

GEOMETRY.

64. *Proposed by L. K. Williams, Hannibal, Mo.*

Construct a triangle having given one angle, a side opposite to it, and the sum of the other two sides.

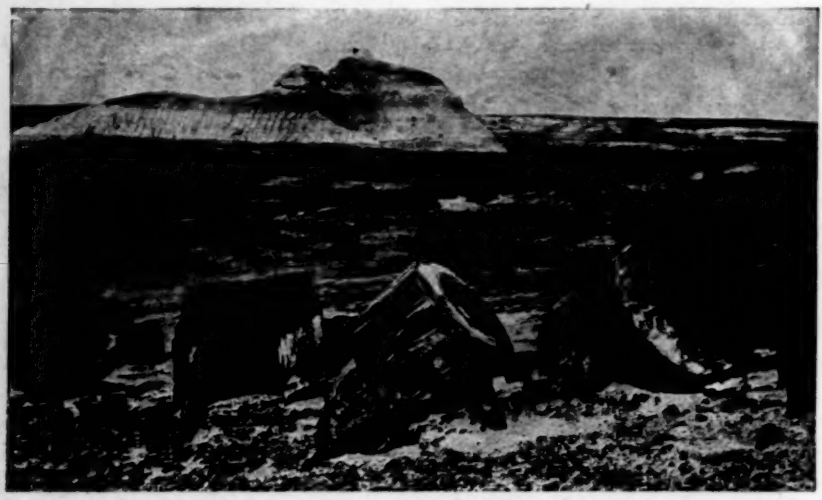
65. *Proposed by I. E. Kline, Blairstown, N. J.*

Determine a point R within a triangle ABC such that angle RAB = angle RBC = angle RCA.

APPLIED MATHEMATICS.

66. *Proposed by H. E. Trefethen, Kent's Hill, Maine.*

A pail whose slant height is 10 inches, bottom diameter 8 inches and top diameter 13 inches is tilted to one side in a rain, so that the water caught rises from its lowest point 5 inches on the bottom and 8 inches on the lower side of the pail. Find the depth of water in the pail when set upright, and also the depth of the rainfall.



PETRIFIED FOREST
(Courtesy of Santa Fe R. R.)

DEPARTMENT OF SCIENCE QUESTIONS.

FRANKLIN T. JONES,

University School, Cleveland, O.

This department is designed to serve as a medium for the exchange of ideas on questions and questioning in the sciences. Questions will be printed from various sources—college entrance examinations, text-books, etc., etc. Comment is invited. Suggestions and criticisms as to character, adaptability, and usefulness are desired. Readers of this journal are invited to propose questions and problems which will be of general interest, or of a type which will be useful in the class-room. It is not expected that questions which will not be useful to pupils will be frequently printed.

Since the majority of the questions will be of a comparatively simple character, solutions and answers will not be published unless specifically asked for. Teaching suggestions are wanted.

Address all communications to the editor of the department.

(DEPARTMENT OF SCIENCE QUESTIONS.)

The number of responses to the questions in the March, 1907, issue is quite satisfactory. Discussion of the questions proposed in the March and April numbers will be taken up in the June issue.

Below are printed the questions used by the College Entrance Examination Board in June, 1906. Teachers of the respective subjects are earnestly requested to examine the papers carefully and send in their opinions to the Editor. Comment will be published in a later issue. It is to be remembered that these questions are set before students *at the end* of the year's work. Attention is particularly directed to the following points—

(*a*) Are the questions of the right kind? Are they tests of memory or of attainment? Are they too technical? Are they too general?

(*b*) Are they too difficult? Are they too simple?

(*c*) Do they presuppose more work than can be satisfactorily covered in a 5-period course for one year, *i.e.* 45-minute periods, a double laboratory period counting as a single recitation period?

(*d*) Is the time allotted for answering the questions sufficient? Are there too many questions for the time allowed?

(*e*) Are the questions fair to teacher and pupil? Are unusual points touched upon? Are "catch" questions asked? Are the questions on fundamentals?

(*f*) Which particular questions are to be especially commended? Which are to be criticised?

BOTANY

MONDAY, June 18, 1906 3.45—5.45 P. M.

Answer any nine of the following questions.

In this examination 37 counts will be based upon the laboratory note book, and 63 upon the following questions:

1. Briefly describe, sketch and name the parts of some complete flower, telling what the function of each part is.

2. Show in cross-section the structure of an ordinary leaf-blade, naming the different structures.

3. For what special functions other than the ordinary and typical ones may the root, stem and leaf become modified? What are the names of the resultant structures?

4. What do you know of the structure of a living plant cell?

5. What raw materials are absorbed into a green plant? From what sources? By what organs? What use is made of these raw materials?

6. What is transpiration and what does it mean to the plant? How is its amount determined by experiment? Under what conditions does the amount become more or less?

7. What different methods of fertilization in the plant kingdom do you know? Describe each with sketches.

8. Describe the life history of some pteridophyte.

9. What are the differences between monocotyledons and dicotyledons? Name four families and twelve species of each group.

10. What are the leading natural groups into which the plant kingdom is classified? Give the leading characteristics of each group.

11. Name five typical algae and five fungi, adding a few words descriptive of each.

12. What do you understand by (*a*) ecology, (*b*) physiology? Illustrate by brief descriptions of typical examples other than any mentioned in this paper.

EXAMINERS

WILLIAM F. GANONG	HENRIETTA E. HOOKER	LOUIS MURBACH
Smith College	Mount Holyoke College	Central High School, Detroit, Mich.

CHEMISTRY

FRIDAY, June 22, 1906 — 3.45—5.45 P. M.

Answer seven questions as indicated below.
In this examination 30 counts will be based on the laboratory note book submitted by the candidate, and 70 counts on the following questions:

A

Answer both questions in this group.

1. Ice melts upon the application of heat, while wood chars. Explain briefly why one of these changes is regarded as chemical and one as physical.
   State and illustrate the law of definite proportions.
   Define briefly the terms (*a*) reduction, (*b*) neutralization. Give an illustration of each.
   Give at least two reasons for the belief that the oxygen and nitrogen of the atmosphere are not in chemical combination.

2. Complete three of the following equations, using formulas:
   iron+sulphuric acid=
   zinc oxide+nitric acid=
   calcium hydroxide+carbon dioxide=
   marsh gas+oxygen (ignited)=
   hydrogen sulphide+lead nitrate=
   Classify the compounds given below into (*a*) acids, (*b*) bases, (*c*) salts, (d) anhydrides: SO_3, $NaNO_2$, HBr, $Ba(OH)_2$, $CaSO_4$, P_2O_5, H_3BO_3, NH_4OH, H_3PO_4, CO_2.

B

Answer only two questions from this group.

3. State, from personal experience, how carbon dioxide was prepared in the laboratory, and write the reaction involved. State two properties of carbon dioxide which were ascertained by experiment, and describe these experiments briefly.
How may it be shown that carbon dioxide is one of the products of respiration?

4. How may chlorine and hydrochloric acid gas be obtained, starting from common salt in each case? In what chemical way may these two substances be distinguished from each other? What is the nature of the bleaching action of chlorine?
Give reasons why the halogens are regarded as members of a natural group of elements.

5. How may hydrogen sulphide be prepared? State three of its properties. What products are formed when a jet of hydrogen sulphide burns in air?
Give two characteristic properties of concentrated sulphuric acid, and two important uses to which this acid is put. Explain its action upon wood.

C

Answer only two questions from this group.

6. What is the nature of the most important chemical change which occurs during the production of pig iron from its ores in the blast furnace? How does a steel differ chemically from a pig iron? Give the names of two processes for the production of steel from cast iron. Define the terms ore and flux.
Give the chemical name and formula of two important compounds of iron.

7. Name two compounds of sodium which are commonly employed in the household, and give the uses of each.
What are the constituents of common gunpowder? What is the formula of caustic potash?
What is a commercial source of ammonia? How may its great solubility in water be demonstrated?

8. What do you consider the most important compound of (*a*) nitrogen, (*b*) chlorine, (*c*) carbon? Give a reason for your selection in each case.
How may water be freed from (*a*) insoluble solid matter, (b) dissolved salts, (*c*) dissolved air?
Hydrogen is produced by the action of sulphuric acid upon metallic zinc. What other substances might be substituted for zinc? Explain clearly why nitric acid could not be substituted for sulphuric acid.

D

Answer only one question from this group.

9. What volume of oxygen, measured under standard conditions, will be evolved when 108 grams of mercuric oxide are decomposed by heating?
What will be the volume of this oxygen at 770 mm. pressure and 27° C.? (Atomic weights: Hg=200, O=16. Weight of 1 liter of oxygen under standard conditions is 1.43 grams.)

10. What weight of ammonium chloride, when acted upon by calcium hydroxide, is required to produce 17 grams of ammonia gas, and what weight of calcium chloride is formed at the same time? (Atomic weights: N=14, Cl=35.5, Ca=40.)

EXAMINERS

HENRY P. TALBOT
Massachusetts Institute of Technology

LOUIS M. DENNIS
Cornell University

CHARLES M. ALLEN
Pratt Institute, Brooklyn, N. Y.

GEOGRAPHY

FRIDAY, June 22, 1906 3.45—5.45 P. M.

In this examination 40 counts will be based on the laboratory note book, and 60 counts on the following questions.
Answer eight questions as indicated below.

A. THE EARTH AS A GLOBE

Answer one question from this group.

1. Give reasons for believing that the earth is a sphere. Where and how much does the earth vary most from this form? State precisely the effect of this variation on the degrees of latitude.

2. Define the solar system and describe the earth's orbit. What is meant by the *eccentricity* of the earth's orbit?

B. THE OCEAN

Answer two questions from this group.

3. Off the coast of Labrador large icebergs are found to move steadily southward, notwithstanding the fact that winds blow in contrary directions. These icebergs neither pitch nor roll, no matter how high the waves may run. Explain their behavior in both these particulars. How are large icebergs formed?

4. What difference is there between a vertical temperature section in the Mediterranean Sea and one in the Atlantic Ocean? Give an explanation of the difference.

5. Show how the form of shore cliffs varies with the firmness and the structure of the materials eroded. Define barrier beach, bar, spit. Are such features confined to the Ocean borders?

6. Name three modes of origin of islands in the Ocean and give a brief explanation of the process in each case.

C. THE ATMOSPHERE

Answer two questions from this group.

7. What is meant by isothermal line, barometric gradient, the dew point, cyclonic area, relative humidity? Describe the method of measuring relative humidity.

8. Describe the way in which weather forecasts are made, and the preparation of the daily weather map.

9. Make a rough sketch map of the United States and represent on it a typical winter cyclone in the temperature latitudes, giving isobars, and wind direction, and locating areas of precipitation.

10. Locate the belts of permanently high and low pressures over the earth and account for them.

D. THE LAND

Answer three questions from this group.

11. Define mantle rock and till, and name the processes which have produced each formation.

12. Locate, describe and contrast the subaerial or exposed and the submarine portions of the Atlantic Coastal Plain Province.

13. Draw a drainage map of North America, naming and briefly describing the great drainage basins of this continent.

14. Define the following, giving an example of each: fall line, canyon, interior basin, mature valley. What is a drumlin? Name a region in which drumlins are found.

15. Compare New England with the prairies of the upper Mississippi States as regards the influence on human life, of two or three of the following geographic conditions; geographic position, topography, climate, soils, mineral resources and opportunity for navigation and other modes of transportation.

EXAMINERS

ALBERT P. BRIGHAM, Colgate University
FLORENCE BASCOM, Bryn Mawr College
WILLIAM H. SNYDER, Worcester Academy, Worcester, Mass.

PHYSICS

MONDAY, June 18, 1906 — 3.45—5.45 P. M.

In this examination 30 counts will be based on the laboratory note book submitted by the candidate and 70 counts on the following questions. The candidate is to answer seven questions, as indicated below.

A

Answer two questions in this group.

1. A glass tumbler may be filled with water till the surface of the water rounds up above the rim of the glass. Why does not the heaped up water spill over? Mention two other illustrations of the principle involved in your explanation.

2. What is meant by the moment of a force? How is the moment of a force measured? Illustrate the general law of moments by a number of forces in one plane acting upon a body in equilibrium. Give a diagram.

3. Briefly state the law of loss of weight of submerged bodies and the law of displacement of floating bodies.
If the specific gravity of a body be 2.0, how much will a cubic centimeter of it weigh in water? What volume of it will weigh 50 grams in water?

B

Answer two questions in this group.

4. A ball is rolling up a smooth incline at the rate of 15 cm. per second and loses velocity at the rate of 3 cm. per second. How far up the incline will it move before coming to rest?

5. How may the weight of a stick be found by using a single weight, an edge upon which to balance the stick, and a meter rule? Explain your method. Give a diagram.

6. Approximately how deep must a bottle, neck downwards, be sunk in water in order to reduce contained air to half its initial volume? What law of gases applies to the case?

C

Answer two questions in this group.

7. If wind instruments were tuned cold, would the pitch of their tones be too high or too low after they had been warmed by the breath in playing? Give a reason for your answer.

8. Describe a laboratory experiment for determining the amount of heat given out by one gram of steam in changing from steam under normal pressure to water at a temperature of 100° C. What weights should be most carefully taken? Why?

9. A candle flame is 150 cm. from a screen which receives an image four times as wide as the flame itself. If a double convex lens is used to project the image, at what distance from the candle must the lens be placed and what is its focal length?

D

Answer one question from this group.

10. Describe a method of determining the resistance of a battery by means of an ammeter and a set of known resistances.

11. With a diagram and discussion show the advantages of a shunt-wound motor over a series-wound motor.

12. Make a drawing showing a bar electromagnet. Indicate the direction of the current by arrows parallel to the wire, and mark the ends of the bar "N" for north-seeking and "S" for south-seeking poles. Inasmuch as the bar derives all its magnetic strength from the current about it, why is the combination of bar and helix a more powerful magnet than the helix alone?

EXAMINERS

EDWARD L. NICHOLS, Cornell University
FRANCIS C. VAN DYCK, Rutgers College
FRANK ROLLINS, Stuyvesant High School, New York, N. Y.

WORK OF THE PAST SEASON IN SOUTHEASTERN ALASKA.

The investigations of the United States Geological Survey during the past season in southeastern Alaska were productive of several valuable results, but none of them is of more general and scientific interest than the survey of the ice fields in Glacier Bay.

This work was in the hands of Messrs. C. W. and F. E. Wright, who were assisted by Mr. R. W. Pumpelly.

With a few exceptions the glaciers are all receding very rapidly, and this fact is especially noticeable at Muir, the best known of the Alaskan glaciers. The front of this ice stream, which was confined to a narrow neck during the last decade, has receded, since 1899, a distance of 5 to 6 miles into much broader portions of the inlet, so that the present ice front, instead of being 2 miles across, forms a hemicircle nearly 7 miles around. This recession has been attributed to the earthquake of 1899, which may have had some effect upon the glacier, but the chief cause of this remarkable retreat is undoubtedly due to its recession into the much wider portion of the inlet, thus exposing a far broader ice front to the action of tidal currents. The other glaciers tributary to Glacier Bay have suffered similar changes, and owing to the vast number of icebergs that are constantly thrown off, the bay is no longer navigable, except in small boats along the shore line. Excursion trips to Muir Glacier, which in past years have been a feature of the Alaskan voyage especially attractive to tourists, will not be possible for a few years to come.

The results of these investigations were most encouraging. Many stratigraphic and structural relations formerly in doubt were made definite. Certain mineral belts were determined, and deposits of nonmetallics such as gypsum, marble, and granite were studied with a view to ascertaining their economic value.

The results of the Survey's investigations in this field will ultimately be embodied in a report on southeastern Alaska. In the meantime economic reports on restricted areas of the field or special subjects will be published as rapidly as the data become available.—*U. S. Geol. Survey, Bulletin 260.*

REPORT OF THE COMMITTEE ON CO-OPERATION[1]

By C. E. Peet, *Lewis Institute*, and W. S. McGee,

Hyde Park High School, Chicago.

In its report your committee has interpreted the resolutions of last year in a broad way and has sought to canvass the field to ascertain what benefits may be obtained through coöperation in gathering materials which will aid in the teaching of the earth sciences. The report makes no pretense to be exhaustive but the intention is simply to open up the field and leave to the future its full cultivation.

The lines of profitable co-operation may be grouped into three main groups:

I. The collection and exchange of informational, illustrative, and museum material.

II. Co-operation in securing legislation.

III. Co-operation in securing positions appropriate to the needs of the instructor.

I. *Collection and exchange of informational, illustrative and museum materials.* There are already great organizations spending hundreds of thousands of dollars (in the aggregate) annually, in gathering and disseminating information that we need. Some of these organizations like the United States Geological Survey publish bibliographies of the literature of the subject, so that there is a way to find the information contained in these publications.

(1). We need a bibliography of bibliographies.

(2). We need also to extend the bibliographies to special subjects so that they will cover the literature adapted to the student as well as that adapted to the teacher. Such bibliographies should include magazine articles as well as books of travel, and scientific publications and should indicate the age of the student for which the literature is appropriate. If all the bibliographies were known and if they covered the field perfectly the fact would still remain that much of the material wanted is unobtainable and much of the material that is obtainable is in unavailable shape.

From the vast reservoir of information within the United States Government and State survey reports we could be supplied with much material we need in our teaching of geology, physiography and geography. This vast amount of material should be drawn upon and put into shape adapted for the use of the student.[2] It should then be published so that it will be within the reach of all. In an ideal co-operative organization the cost of such material should be the mere cost of paper and printing. We are confident that should a movement be set on foot to put this information into a form adapted to the needs of the young it would receive the hearty co-operation of not only the State Geologists but the heads of the great Government bureaus and

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1 Read before the Earth Science Section of the Central Association of Science and Mathematics Teachers, December 1905.

2 Two books have recently appeared (1907) which make a step in this direction. They are Condra's Geography of Nebraska and the Geology and Physical Geography of Wisconsin by E. C. Case.

other great institutions serving the public just as we are trying to serve it. We venture to say that there would be no difficulty in obtaining illustrations both from these institutions and from the railroads and other transportation companies. The possibilities of this means of supplying illustrative material at a very small cost do not begin to be appreciated.

(3). Were all this done, gaps would still be found that need to be filled. In the study of various parts of the world through the topographic maps, detailed information which is not now available is frequently needed to understand the cause of the location and growth of villages and cities, peculiar forms of boundary lines, the historical significance of the names, and numerous other things. This information should be available so that the student can look up these things and satisfy himself that there are reasons for them. The information first supplied should be for those regions covered by the topographic maps commonly studied. Along with this literature should go pictures so described that the student would understand just what part of the region on the map the photograph represents. Such illustrations would greatly aid the student in picturing the features of the region.

There are county histories from which some of the information desired could be extracted by those competent to judge of its value. By cooperation with the history teachers' associations such information should soon become available. Every teacher of the earth sciences or of history should be a source of definite information for his own locality as to the history of settlements and the growth of the cities and the causes therefor.

This work should finally result in the publication of monographs on the different physiographic districts and their natural subdivisions, covering the topography and its history, the life of the district including the aboriginal inhabitants and their adaptions to environment, accounts of early explorations with their relations to the topography, accounts of the early settlements, the origin and significance of the names of places, the causes for the location of villages and cities including the successive factors in their growth and the changes in village sites and the causes, and finally the present industries and occupations of the people. Such a monograph as is planned by the Geographic Society of Chicago on Chicago might well be planned for every city of fair size and for groups of cities of smaller size.

(4). While satisfying the demands for information in geology, physiography and geography is important, of still greater importance is the gathering of information bearing on the educational problems connected with the teaching of these subjects. A system of coöperation should result in the appointment of a special committee to gather information as to the needs of the student at each of the stages in which he is under our care.[3] This investigation should seek to discover what are the interests of the student, what things appeal to him most, what things produce in him the greatest growth in the right direction, what his demands at each stage are, and the best means of creating in him

3 Such a committee was appointed at the Chicago meeting, December, 1906.

at each stage the right demands. This committee might well raise the question whether the physiography as now taught (usually in the place in the curriculum appropriate for a general introduction to science), is broad enough to meet the needs of the young student; whether it would not be better to make it frankly a general introduction to science, which shall have its roots in those portions of physics, chemistry and astronomy which appeal to the young student, the portions full of demonstrations and laboratory exercises of the kind which delight the student's heart, arouse his enthusiasm, and increase his desire for more and deeper knowledge. Is this not indeed the time to open the door and let the student look in at the good things that are ahead and to start him happily on the way to acquiring the methods of science? The subject matter could not well stop with the roots of this tree of knowledge, as it were. We already have the trunk in the physiography as now taught generally. Should not the branches and foliage be permitted to grow in the form of geography so taught as to bring out the relations between the physical features of the earth and the life upon it and especially the human life of the present, with its manifold activities and institutions and the stages of growth of these institutions and activities? Such a committee might well get together for supplementary reading a list of books of travel, early exploration and adventure, which would stimulate in the student a desire to travel, create in him a thirst for greater geographic knowledge, widen his horizon and deepen his interest by giving him that background of knowledge which makes physiography interesting to us.[4] Such a selection of books should be made through the students themselves so that it would include the books actually of interest to them, not those in which we think they should be interested. This work might well include the preparation of maps to accompany such books as are not properly supplied with them, and also the preparation of sets of questions that would call the attention of the student to important points in such a way that in answering the questions he will get the profitable points bearing on the geography and physiography. This work might go so far as either to arrange for, or actually include, the production of suitable literature to fill the gaps which now remain unfilled. Such a committee would no doubt receive the cordial co-operation of the public libraries in compiling the lists here suggested. Similar efforts on the part of teachers of other departments have received encouragement and financial aid in publishing the lists. There is danger indeed that the secondary schools will fall behind the grammar schools in this enterprise.

(5). A subcommittee might well devise a system of correspondence similar to that in force among the students of foreign languages by which not only students but instructors would be able to get into communication with all parts of the world and thus gain desired information from those on the ground. That there are difficulties to be over-

[4] Such a list of books was prepared in 1906 and mimeographed copies are now in the hands of volunteers who are testing the books by placing them in the hands of the student and watching the result. It is proposed to print the list when the test is completed and a final selection has been made. The list should be extended to magazine articles answering the same purpose.

come one can readily see, and to those who find it difficult to keep up with their present correspondence these will stand out prominently. Nevertheless, it would seem as though it would be worth while trying. If instructors and students do not take to it, then it should go the way all things go for which there is no demand or for which no demand can be created.

(6 and 7). Collection and exchange of museum and other illustrative materials. We have finally arrived at the topic which no doubt was chiefly in mind last year when the motion was made for the appointment of the committee—the exchange of illustrative materials. Theoretically it seems a nice scheme. It seems as if instructors in the earth sciences, widely scattered, could arrange a scheme of coöperation in the exchange of rocks, minerals, soils, and of museum materials of various kinds arranged in series showing the stages from the original raw material to the manufactured product. It would seem that grains, such as rice, corn, wheat, oats; fibers, such as cotton, wool, flax, hemp; minerals, such as iron, copper, nickel, lead, graphite, and other material, such as rubber, paper, sugar, naval stores, and many other things might be gathered in this way and exchanged. With these should go photographs showing the various stages in the progress of the raw materials to the finished products. Many of the things mentioned are heavy, and a systematic exchange of such materials would necesitate establishing a convenient center to which the materials could be shipped and made up into the proper form. When a sufficient collection had been gathered together different sets could be shipped to each individual coöperating. It would seem as if the entire time of one man might be taken up with gathering, arranging and shipping such materials.

It would seem that those who have constructed models could easily make copies from the moulds and that they might be exchanged direct. Your committee hoped to receive replies from several who we know have made models. We thought that they would be willing to make copies for exchange but we have been disappointed. No doubt, however, with the movement once started, there would be greater freedom in offering, and probably more models would be made were it known that they could be exchanged for others. The present high price of models is a good reason for such a coöperative scheme of exchange.

Almost everybody, whether working in geography or not, has a camera. With the thousands of cameras working in various parts of the world, it would be surprising if exchange of pictures could not supply to all of us those which we need. It ought to be possible to satisfy specific wants through correspondence with individuals, or perhaps better still through communication with some central body in touch with all. Your committee has endeavored through correspondence and through conversation to learn what are the unsatisfied demands of the teachers of the earth sciences and what each one can contribute toward a common or individual need. The returns are enough to convince us that there will be no spontaneous and immediate general participation in a movement to supply materials. If this is to be successful there must be selected out ten or a dozen or fifty people to do

the work in each country. It is plain that where people are as busy as we are, anything which lies outside of our immediate duties as teachers is likely to be neglected. This gathering of material does lie outside of these duties. The gathering of information lies right alongside of our immediate duties. The study of the *interests and needs of the student is an immediate duty.*[5]

II. *Legislation.* In these days of agitation for railroad rate legislation it may not be shocking to propose rate legislation which shall favor the field excursion for educational purposes. It may be hoping for the impossible, but is it not true that transportation for educational purposes should be put on a different basis from transportation for business purposes, and is it not possible that concessions may be wrung by legislation from the railroad officials who resist like adamant the appeals from educators for rates as low as those granted to theatrical troupes?

III. *Coöperation as to positions.* It is looking far into the future, perhaps, and is but putting a dream into words to speak of a system of international migration of instructors in geography, so arranged that in the course of ten years or so one could have resided in several different countries and climates and arrive at the original starting point with a rich store of knowledge and the power of arousing enthusiasm in the student of geography such as can be aroused by one who has had adventures in strange lands. We are hearing nowadays of the exchange of instructors between the great universities of America and Europe. The dream for secondary schools is but a step farther. If such things could creep down from the colleges and universities as rapidly as have football, fraternities, college yells, and college rowdyism, it certainly would not take long for an international exchange of instructors to descend to the secondary schools.

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5 It is more than a duty. It is a *privilege*. It offers that opportunity for *investigation* so much desired by many secondary school instructors and so often urged by the University Professor. The investigator's attitude of mind in the teacher changes the whole aspect of school room problems. It may even make the reading of papers a pleasure. Mistakes, before a vexation, now are items of interest because they show how the studen 's mind is working. It gives the teacher an appreciation of the personality of the individual student that is a pleasure and a never-ending source of interest, and results in bringing student and teacher nearer together, for there is nothing to which the student is so sensitive as to the real feeling of the instructor toward him. The instructor is thus placed in a position of advantage in discovering the hopes and ambitions that lie deeply concealed in the heart of the student. When these things are known the problem of satisfying the demand of the student or of stimulating in him demands that will result in his greatest growth may be attacked by the methods which the scientist is accustomed to use in the solution of his problems. Is it not a reflection on the scientific methods of the science teacher that so much time has been given to studying how to teach the subject and so little time has been given to studying what the nature of the student demands at the successive stages of his growth?

PHOSPHATES OF NORTHERN ARKANSAS.

An exhibit at the Louisiana Purchase Exposition in St. Louis that attracted a great deal of attention was a solid block of phosphate rock 4 feet wide, 8 feet long, and more than four feet high. It was exhibited by the Arkansas Fertilizer Company, the company operating the phosphate mines and the fertilizer plant on Lafferty Creek, Independence County, Ark. So many questions were asked about the deposit from which it came that Mr. A. H. Purdue of the United States Geological Survey, who had arranged for the exhibit, made a special trip to Arkansas last August for the purpose of studying the developed phosphate beds of that region. He afterward prepared a brief report on the subject will soon be published in the Survey's forthcoming volume "Contributions to Economic Geology, 1906."

The only point where the phosphate deposits of Arkansas are now worked is a quarry from one half to three fourths of a mile east of White River. These deposits have a wide east-west extent, reaching from the town of Hickory Valley, 10 miles northeast of Batesville, westward at least as far as the town of St. Joe in Searcy County, a distance of more than 80 miles on a direct line. While it is certain that prospecting for workable deposits throughout most of this distance would be useless, it can confidently be expected that other points than those now known will be discovered where the rock can be mined with profit. Especially is this true of the eastern part of the field.

The credit of the discovery of these deposits belongs to Dr. J. C. Branner, formerly State geologist of Arkansas. Many observers had noted them, but their true nature was not known until Dr. Branner in 1895 made analyses of the rock in the laboratory at Stanford University.

In June, 1900, a company was organized for the development of the phosphate beds along Lafferty Creek. A mining and milling plant was erected, which was later destroyed by fire. A much larger plant has recently been erected at Little Rock. It has an annual capacity of 40,000 tons with a shipping capacity of 15 to 18 cars a day.

The phosphate rock is of sedimentary origin. Where developed, it is light gray, homogeneous, and conglomeratic, the pebbles being the size of peas and smaller. There are two well-defined beds, but only the upper one is worked, the lower being considered too low in grade for further exploitation. The aggregate thickness of the two beds is from 8½ to 10 feet.

The beds were probably put down near shore, as the sea advanced landward. Their phosphatic nature is thought to be due mainly to the organic fragments that constituted so large a portion of their mass, though it may be due in part to the droppings of marine animals.

Persons interested in fertilizers and the phosphate deposits of the country will find in Mr. Purdue's paper a description of the developed deposits of Arkansas with some discussion of the geology of the region.

THE RECESSION OF NIAGARA FALLS.

Probably no one who has looked down on the falls of the Niagara River and the grand canyon they have carved for themselves out of the solid rock but has felt his brain oppressed with the idea of eternity and the incomprehensibility of it. It is a thought that will be driven home to those who may read the recent pamphlet of Mr. G. K. Gilbert of the United States Geological Survey concerning the rate of recession of Niagara Falls. Not only does he tell us that the great falls are not what they have been within the memory of man, and show us pictures and maps to prove that their outline has changed, but he gets out his tape line and measures the distance that they have receded within certain years.

The data for computing the rate of recession of Niagara Falls include surveys of the crest line made in 1842, 1875, 1886, 1890, and 1895, and cameralucida sketches made in 1827. During the period covered by these data the rate of recession has not differed to an important extent from the natural conditions. The present and prospective diversions of water for economic uses interfere with the course of nature and may be expected to modify the rate of recession.

The rate of recession of the Horseshoe Fall, or the rate of lengthening of the Niagara gorge, during the sixty-three years from 1842 to 1905 is found to be five feet per annum, with an uncertainty of one foot. For the thirty-three years from 1842 to 1875 the rate was apparently slower than for the thirty years from 1875 to 1905. The rate of recession of the American Fall during the seventy-eight years from 1827 to 1905 was less than three inches per annum.

The time consumed in the recession of the falls from the escarpment at Lewiston to their present position, or the age of the river, is not here estimated. It can not properly be computed without taking account of all conditions, local and temporary, affecting the rate of recession, and some of those conditions have varied greatly from point to point and from time to time.

Mr. Gilbert's report is published as Bulletin No. 306 of the Geological Survey. It is accompanied by a report on the survey of the crest line of Niagara Falls by Mr. W. Carvel Hall, who made the survey in June, 1905. The work was done under a plan of coöperation between the Survey and Mr. Henry A. Van Alstyne, State engineer of New York. Mr. Hall adds two tables to his report, one showing the artificial monuments and other permanent reference points connected with the triangulation of the surveys, the other the distance between permanent reference points.

COVE CREEK SULPHUR BEDS, UTAH.

A glimpse of Hades itself—and what is worse—the smell of it—may be obtained at Sulphurdale, Utah, where sulphur is apparently in process of formation and concentration. Here and at several other localities in the neighborhood are valuable deposits of sulphur, which

have attracted the attention of Mr. Willis T. Lee of the United States Geological Survey, who has recently visited them and now describes them in the Survey's forthcoming volume "Contributions to Economic Geology, 1906."

Sulphurdale is a small mining camp about twenty miles north of Beaver, Utah, the nearest town of any considerable size. The deposits, which are owned by the Utah Sulphur Company of Salt Lake City, are situated about four miles south of the site of old Cove Fort, and are locally known as the Cove Creek sulphur beds. Cove Creek sulphur has supplied the local market for about thirty years, the average annual output being estimated at one thousand tons. An area of several acres has been exploited, but the lateral extent as well as the depth of the deposits is unknown.

Some of the sulphur occurs in cylindrical masses or cores ten or fifteen feet in diameter, having a rude radial structure as if they had been formed about a central vent extending indefinitely downward into beds of tuff. But it occurs mainly as a dark-colored impregnation or cementing substance in the rhyolitic tuff. In certain places it appears as irregular veins of nearly pure yellow sulphur ramifying through the beds. Occasionally a smaller cavity is found lined either with flowers of sulphur or with sulphur crystals.

This sulphur is probably the result of volcanic action, as shown by its presence in a volcanic region where recent eruptions have occurred. Gas is escaping in large volumes, in some areas by thousands of small jets from the porous beds of tuff. Wherever water is found standing in the excavations, the gas is noted boiling up through it at short intervals. The disagreeable odor of hydrogen sulphide is strong, and it is probable that this gas is the origin of the sulphur, the hydrogen in the gas uniting with the oxygen in the porus tuff to form water, and leaving the sulphur behind as a solid.

The ore varies in richness from a trace to practically pure sulphur. Samples taken at the extremities of the workings and analyzed in the laboratory of the Geological Survey were found to contain respectively eighty per cent and sixty-five per cent of sulphur. Material running as low as fifteen per cent sulphur is considered paying ore.

At the smelter, the ore is placed in iron retorts and the sulphur is melted out by steam. Analysis of the product, as it comes from the retorts, shows that it contains 99.71 per cent sulphur, .23 per cent non volatile residue, and .06 per cent of moisture.

ARTICLES IN CURRENT MAGAZINES.

Forestry and Irrigation for April: "Forestry in the Middle West," "National Forests at Close Range," "Fish and Irrigation Ditches," "Wood Paving," "United States Timber Supply," "Millions for Moisture," "Senate Debate on National Forest Policy," "Improving the National Forests."

Popular Science Monthly for April: "Pioneers of Science in America," with portraits; "Notes on Development of Telephone Service," Fred DeLand; "The General Economic Importance of Mosquitoes," Professor John B. Smith; "The Value of Science," M. H. Poincaré; "The Reclamation of the North Platte Valley," W. S. Coulter; "How Shall the Destructive Tendencies of Modern Life be Met and Overcome?" Dr. Richard Cole Newton.

Farming for March: "The War with the Insects," Dwight Sanderson; "Testing of Corn for Seed," Prof. A. N. Hume; "The Price of Success in Western Canada," Agnes C. Lant.

Science for March 29: "The Factors of Safety in Animal Structure and Animal Economy," S. J. Meltzer; "The Limitations of Isolation in the Origin of Species," C. A. Kofoid; "Note on a Tertiary Basin in Northern Alaska," E. M. Kindle. For March 15: "River Capture in the Tallulah District, Georgia," D. W. Johnson. March 22: "Clocks—Ancient and Modern," W. S. Eichelberger; "Henri Moissan," C. G. Doremus.

School World for March: "The Metric System," by R. Wyke Bayliss; "Recent Contributions to the Study of Chemical Change," by W. A. Davis; "The Best Curricula for Secondary Schools," by G. McCroben.

Nature Study Review for February: "Practical Work with Mosquitoes," C. F. Hodge. "Children's Gardens," G. H. Trafton; "Home Gardens in Cleveland," Lucy C. Buell; "Agriculture in Public Schools," W. C. Latta.

Monthly Weather Review for December, 1906: "Salton Sea and the Rainfall of the Southwest," A. J. Henry; "Changes of Latitude and Climate," "Villards Theory of the Aurora," W. R. Blair; "Problems in Meteorology," C. F. von Hermann.

Scientific American for March 23: "Controlling Torpedoes by Wireless Telegraphy," "Autogenous Welding with the Oxy-Acetylene High Pressure Blowpipe." March 16: "Tablet Writings from the Ruins of Nippur," "Carborundum and Silicon Detectors for Wireless Telegraphy," "Leducs Artificial Plants and Cells." For March 30: "The Story of Malaria," by L. H. Yates; "A New High Speed Photographic Shutter," "Pierre Berthelot," "Metallic Sodium as a Conductor for Electric Currents."

Ores and Metals for March 30: "Placer Mining Hints," "Characteristics of Building Stones," "Points on Zinc Metallurgy."

American Inventor for March: "Our Forests," by W. Fawcett; "Oregon's Nickel Deposits," "Day and Night in the Polar Circle," by F. R. Hovey.

Technical World for April: "To Unite a Hundred Rivers," Frank A. Briggs; "Farmer Fears Weeds no Longer," May Wood-Simons; "Vast Profits in the Golden Goat," René Bache; "To Save the World from Famine," F. A. Talbot; "Last Days of the Fur-Seal," P. T. McGrath; "Cutting Steel by Electricity," J. Mayne Baltimore; "Sunlight Made to Order," Eugene Shade Bisbee; "Prairies Spout Great Riches," Geo. W. Harper; "From Sheet Steel to Bathtub in Six Minutes," James Cooke Mills; "Plants Under Acetylene Sunshine," William T. Walsh.

Photo Era for March: "A Plea for the Stereopticon," by W. Green; "A Practical Introduction to Lantern Slide Making," by T. Perkins.

Reviews of Reviews for April: "The Doctor in the Public School," by J. J. Cronin, M.D.; "The Making of a Forest Ranger," by Arthur Chapman; "The Revolution in Chicago's Judicial System," by Stanley Waterloo; "Reducing the Railroad Death Rate," by Arthur M'Tavish; "Railway Accidents and Personnel," by W. W. Randall; "Psychology of Railroad Accidents," by C. R. Keyes.

Scientific American Supplement for March 30: "The Fight Against Yellow Fever," "Light and Illumination," "The Buried Cities of Ceylon." For March 23: "Hybridization of Oaks." For March 16: "The Distillation and Rectification of Alcohol," "The Electrification of the Simplon Tunnel Railroad." For March 9: "The Technology and Use of Peat." For April 6: "The Deserts of Nevada and the Death Valley," "The New Inland Sea," "The Planet Mars as Revealed by Recent Observations."

Physical Review for March: "Modifications of the Maxwell-Rayleigh and the Anderson Methods for the Measurement of the Coefficient of Self-induction," "The Absorption of Hydrogen by Metal Films," "On the Susceptibility of Mixtures of Salt Solutions," "Researches on the Forms and Stability of Aëroplanes," "On the Nature of Optical Images," "Radiation from Selectively Reflecting Bodies."

School Review for April: "The Difficulty of the High School Library, and a Suggestion," "A Successful High School Library," "My Struggle with the Italian Language and the Morals I Drew from It for the Teaching of Mathematics," "The Standardization of the New England High Schools."

The Open Court for April: "The History of Spectacles," (illustrated); "In the Mazes of Mathematics: Geometric Puzzles."

REPORT OF THE MEETING OF THE NEW JERSEY SCIENCE TEACHERS' ASSOCIATION.

The second meeting of the New Jersey Science Teachers' Association was held at Rutgers College, New Brunswick, in January. A constitution was adopted and the following program carried out:

Mr. J. E. Peabody of the New York City Schools gave a paper on the Course in Biology in the New York State Schools. He traced the history of Biology teaching in the schools of New York City and gave the following outline as a sample of the work that is being done there:

Biology I.

Flowers, 18 lessons; trees, 5 lessons; fruits and seed dispersal, 8 lessons; topics in Physics and Chemistry, 10 lessons; food tests, 6 lessons; seeds and seedlings, 15 lessons; roots, 5 lessons; stems, 7 lessons; leaf structure and food manufacture, 5 lessons; Cryptogams (Yeast, Bacteria, Spirogyra), 10 lessons.

Biology II.

A. Animal Studies.

Insects (locust, bee, butterfly), 15 lessons; crayfish, 9 lessons; earth, worm, 5 lessons; amoeba and paramoecium, 5 lessons; frog, 12 lessons.

B. Human Physiology.

Foods, 8 lessons; digestion and absorption, 10 lessons; blood, 4 lessons; circulation, 10 lessons; respiration, 4 lessons; bacteria and sanitation, 7 lessons. (Throughout the study of human physiology emphasis is laid on the physiological importance of proper food, air, exercise and rest.)

Prof. F. C. Van Dyck of Rutgers College gave an address on "The Teaching of Mechanics." He emphasized the need of thorough preparation in Mechanics as a basis for further work in College. He showed how one subject, that of leverage, might be presented so as to enforce the necessity of keeping the conceptions of work and energy uppermost. He showed several pieces of apparatus to illustrate his points: "Tip-toe Apparatus," a suspended model of a boat, to illustrate the leverage of an oar, and a fixed pulley by which one may lift himself.

Mr. H. M. Campbell of Long Branch demonstrated a piece of apparatus for the teaching of light, in which the path of reflected and refracted rays under various conditions could be plainly seen.

After luncheon a visit was made to the model farm, where Director Voorhes explained the purpose of the courses and referred especially to the short courses in Agriculture which have been recently instituted during the winter for the benefit of farmers and others who are not able to take the full course.

In the afternoon, Dr. Smith of Rutgers College, State Entomologist, read a paper on "How Entomology Might be Taught." In order to test the capabilities of observation of his pupils it is his custom to hand the student a large beetle and ask him to describe it. From this a teacher may judge what further directions each pupil needs. Taking the house fly as an example he suggested that the following lessons might be learnt from it.

1st. The division of the body into three regions may be clearly brought out.

2nd. The jointed character of the leg is clearly defined. In this connection a study may be made of the mode of walking.

3rd. The veined character of the insect wing is easily shown.

4th. The feeding habits of the fly may be studied and the structure of its feeding organs.

5th. The compound eyes and antennæ may be studied, and the fly's senses of vision, touch and smell tested.

6th. A careful study will reveal individual differences between various flies. There is quite an opportunity to test the sensitiveness of the fly, but these experiments are not adapted for younger pupils.

7th. The development of the fly is rapid and may be easily watched.

8th. The maggot illustrates adaptations to surroundings.

9th. The change from larva to pupa furnishes an instructive lesson.

10th. The hibernation in the adult state is a necessity from its life history. The bee was suggested as another insect which might be studied with profit and interest.

On account of the lateness of the hour the paper by Mr. A. T. Seymour on "What the Association May Do for Science Teaching," was omitted.

For the evening, the New Jersey State Microscopic Society arranged a special program for the benefit of the members of the Science Teachers Association.

The next meeting of the Association will be held in the spring at Princeton University. GILBERT H. TRAFTON, Secretary.

ASSOCIATION OF TEACHERS OF MATHEMATICS IN THE MIDDLE STATES AND MARYLAND.

The eighth meeting of the Association was held in Teachers College, New York City, Saturday, April 6, 1907. Fifty new members joined the Association.

Official announcement was made of the organization of two new sections. The Pittsburg Section was organized January 25 under the following officers: President, John J. Quinn, Scottdale, Pa.; Secretary and Treasurer, J. Buell Snyder, Perryopolis, Pa.; Executive Committee, F. G. Masters, John H. Bortz, and J. H. Eisenhauer. The section has held two profitable meetings and the work of the Association is exciting a keen interest among the progressive teachers of Western Pennsylvania.

The Rochester Section was organized February 23d, 1907. An account of the initial meeting was given in the April number of SCHOOL SCIENCE AND MATHEMATICS.

The officers of the Section are President, Arthur S. Gale, Rochester; Vice-President, Charles C. Grove, Clinton; Secretary, Fred L. Lamson, Rochester; Executive Committee, Edward D. Graber, Geneseo, and William Betz, Rochester. Meetings will be held on the second Saturday of October, February, and April.

In addition to the reports from the newly organized sections, the older sections of the Association at Philadelphia and at New York presented reports showing energetic and helpful work.

After minor matters of business were transacted, the following papers were read:

1. Some Problems in the Teaching of Elementary Mathematics, George H. Hallett, University of Pennsylvania.

2. Zero and Infinity: William H. Maltbie, The Woman's College, Baltimore.

3. The History of Computation (Illustrated): David Eugene Smith, Teachers College, New York.

4. The Early Mathematical Instruments in Modern High School Teaching: William E. Stark, Ethical Culture School, New York.

Professor Hallett found the best remedy for the weakness and faults of secondary and college students in mathematics to be a more thorough training of the teacher in both pure and applied mathematics and in the art of teaching.

Dr. Maltbie called attention to many inaccurate and inconsistent statements in current text-books in the treatment of Zero, Infinity and Limits.

The illustrated talks of Dr. David Eugene Smith and Principal William E. Stark were of great practical interest. Dr. Smith briefly traced the history of counting, and his slides were views of ancient tablets, manuscripts and text-books. Views of mechanical devices used in Eastern Countries for the simple calculations of buying and selling were also shown and contrasted with them were the modern machines in common use in the counting rooms of banks and large corporations. Dr. Smith suggested the question, "Must not the school room in the near future contain such appliances among its equipment?"

Mr. Stark's slides, like those of Dr. Smith, were chiefly reproductions of illustrations found in old manuscripts and early text-books. They suggested how the ancient forms of astrolabe, quadrants and cross-staves could be used to impress the principles of Geometry in the solution of practical problems. Mr. Stark also exhibited models of such instruments constructed by his pupils. J. T. Rorer, Secretary.

MATHEMATICAL NOTE.

The State Teachers Association of Wisconsin has just published as Bulletin of Information, No. 14, a committee report on The Content of Algebra for High Schools. The Bulletin is issued under the authority of State Superintendent C. P. Cary. The committee that drew the report consisted of the following persons: Jos. V. Collins, Ch.; C. F. Viebahn; E. B. Skinner; Richard E. Krug; H. L. Terry.

The Bulletin makes a neat little pamphlet of 11 pages. The suggestions and recommendations of the committee are included under the captions:

(1) What to omit from the First-Year Course;

(2) What to insert in the First-Year Course; and

(3) In the Advanced Course.

The report is profitable reading to any interested in these three topics. It is assumed that the office of the State Superintendent of Public Instruction, Madison, Wis., will supply any who desire to have the report.

BOOKS RECEIVED.

Exercises in Chemistry, by William McPherson and William E. Henderson. Pp. 69. Exercises 49. Ginn & Co.

A Guide for Laboratory and Field Work in Zoology, by Henry R. Linville and Henry A. Kelley. Pp. 104. Ginn & Co.

Introduction to Metallurgical Chemistry for Technical Students, by J. H. Stansbie, B.Sc. (Lond.), F.I.C., Lecturer in the Birmingham Technical School. 2d edition. Pp. 252. Longmans, Green & Co., N. Y. $1.25 net.

Elements of Geology, by W. H. Norton, Professor of Geology in Cornell College. 1905. Pp. 462. Ginn & Co., Boston. $1.40.

BOOK REVIEWS.

PRELIMINARY REPORT OF THE COMMITTEE ON GEOMETRY, DECEMBER, 1906.

This report of the Central Association's Committee covers nine large pages and, we are reminded it is only a *preliminary* report, is the outcome of a most conscientious and careful year's work by thoroughly competent persons and it will have an immense influence for good on the teaching of this subject in secondary schools.

The subject-matter of the report falls under the following headings:

1. Introduction; 2. Indefinables; 3. Congruence; 4. Terms; 5. Assumptions; 6. Definitions; 7. Use of figures; 8. Redundancies; 9. Pedagogy; 10. Applications; 11. Relation to Algebra; 12. History; 13. Advanced courses in geometry; 14. Diagrams, and 15. Fundamental propositions.

It is clear from this enumeration of headings that the ground has been well covered. A reading of what is said under any of these headings will impress one with the pertinency and current teaching of what is said. It can scarcely be expected that anyone will be ready at once to adopt all the suggestions—nor is this the committee's intention—but no one can study through this extraordinarily valuable report without having his practice in geometric work with young pupils greatly cleansed and invigorated.

Not a few teachers will here learn that they have been spending much time in attempting to define indefinables, some, who have already adopted the committee's viewpoint as to congruency, will be encouraged by the report, many will be helped by the illuminating remarks on Use of Figures, all will read with interest and help what is said about Pedagogy and History. To many it will be helpful to learn from the report how advanced Courses in Geometry will aid teachers of beginners, and no one can fail to give critical study to the list of fundamental theorems and constructions given on the last three pages. A teacher of high school geometry who does not study this report through carefully commits a capital offense against his pupils. A request accom-

panied by a two-cent stamp directed to Miss Mabel Sykes, 438 57th St., Chicago, is all that is needed to procure this greatest contribution to practical geometry teaching of the decade. G. W. M.

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28 Exercises on Topographic Maps. By Mark S. W. Jefferson. 30 pages. 6 figures. Published by the author, Ypsilanti, Mich.

The 28 exercises are based upon 24 maps carefully selected from those published by the United States Geological Survey. The exercises will meet the requirements of a modern course in the high school physiography of the lands. The various exercises are distributed among the different topics as follows: 9 being devoted to the plains and plateaus, 11 to the rivers, 2 to the glaciers, 2 to the shore lines and 3 to contour lines.

The introductory work on the contour lines is below the general standard of the other exercises. It is doubtful if the completion of the exercises here outlined will make clear to the average high-school pupil the meaning of contours. The writer has found that it is lost time to use coloring to develop the idea of relief. It does not seem wise to introduce caldera into the work designed primarily to lead to an understanding of contours as is done in Exercise 3.

The treatment of the Coast Plains (Exercise No. 4) is admirable but is rather lengthy for a single exercise for the average pupil, even if the double period is available. There is a monotonous repetition in all of the exercises of the questions of location, scale and contour interval, this is hardly necessary. The maps should be located and the student become accustomed to use the legend, scale and obtain the contour interval. In each of the exercises the human element receives attention in a rational manner. Some of the relations are especially good, as for example: Lockport, N. Y., and the old cuesta; the Ridge Road at Ypsilanti, Mich., and the old beach lines, roads, and drumlin at Sun Prairie, Wis., and the populous districts along the Mississippi at Donaldsonville, La.

It is believed by the writer that these exercises on the land forms are the best that have been issued, because the matter is placed before the student in concise and definite statements. Teachers of Physical Geography will learn much from this simple little pamphlet, and to those who are teaching with little or no preparation it will be a real aid and an inspiration. It is a refreshing movement in the direction of systematizing physiographic exercises and raising them above the loose nature study methods which have been practiced by various teachers of this subject. WILLIAM M. GREGORY.